APPENDIX 20
Agricultural Impact Statement

umwelt
Environmental & Social Consultants

MANGOOLA
OPEN CUT
GLENCORE

MANGOOLA COAL CONTINUED OPERATIONS PROJECT

Agricultural Impact Statement

May 2019

MANGOOLA
OPEN CUT
GLENCORE

AGRICULTURAL IMPACT STATEMENT

Agricultural Impact Statement

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Mangoola Coal Operations Pty Ltd

Project Director:	John Merrell
Project Manager:	Daniel Sullivan
Technical Director:	Pam Dean-Jones
Technical Manager:	Anne Schneider
Report No.	4004/R11_FINAL
Date:	May 2019

umwelt
Environmental & Social Consultants

Newcastle

75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

Certified System
Quality
ISO 9001

This report was prepared using Umwelt's ISO 9001 certified Quality Management System.

Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Final	John Merrell	17/5/19	John Merrell	17/5/19

Table of Contents

Abbreviations i

Executive summary iii

1.0 Introduction 1

1.1 Project Overview 1

1.2 Project Area and Locality 5

1.3 Report Structure 7

2.0 Assessment Requirements, Project Scope and Approach 8

2.1 Secretary's Environmental Assessment Requirements 8

2.2 Upper Hunter Strategic Regional Land Use Plan 8

2.3 Mining SEPP 10

2.4 Requirements of the Agricultural Impact Statement Technical Notes 10

2.5 Method of Assessment 13

2.5.1 Review of other Biophysical, Social and Economic Studies as they relate to Agriculture 13

2.5.2 Consultation 13

3.0 Agricultural Resources of the Locality 15

3.1 Climate 15

3.1.1 Potential Impact of Climate Change 17

3.2 Topography 17

3.3 Soils 18

3.4 Water resources 29

3.4.1 Surface Water 29

3.4.2 Groundwater 32

3.5 Significant Vegetation Communities 34

4.0 Agricultural Resources within the MCCO Additional Project Area 37

4.1 Vegetation 37

4.1.1 Proposed Disturbance Footprint 37

4.1.2 Proposed Offset Areas 39

4.2 Water resources 39

4.3 Topography 40

4.4 Soil 42

4.4.1 MCCO Additional Project Area 42

4.4.2 Proposed Offset Areas 48

5.0 Agricultural Industries and Productivity of the MCCO Additional Project Area and Locality 57

5.1 Land Ownership in the Locality 57

5.2 History of Agriculture 57

5.2.1 Regional history 57

5.2.2 Local history and Historical Land Uses of Wybong 59

5.2.3 History of Agricultural Industries of the Upper Hunter and Wybong 60

5.3 Agriculture in the MCCO Additional Project Area, Locality and Muswellbrook LGA 60

5.3.1 Farming in the MCCO Additional Project Area 60

5.3.2 Farming in the Proposed Offset Areas 62

5.3.3 Farming in the Locality 62

5.3.4 Muswellbrook LGA 64

5.3.5 Agricultural Communities 72

5.3.6 Supporting Infrastructure 74

6.0 Assessment of Impacts 75

6.1 Rehabilitation and Post Mining Land Use 76

6.1.1 Rehabilitation Objectives 76

6.2 Impacts on Agricultural Resources in the MCCO Additional Project Area 76

6.2.1 Impacts on Landform 76

6.2.2 Impacts to Land Capability 77

6.2.3 Impact on Soils 79

6.2.4 Potential Physical Movement of Water away from Agriculture 80

6.3 Impacts on Agricultural Resources in the Offset Areas 83

6.4 Impacts on Agricultural Enterprises/uses in the MCCO Additional Project Area and Proposed Offset Areas 84

6.5 Impacts on Agricultural Resources and Uses in the Locality 85

6.5.1 Water Resources 85

6.5.2 Blasting, Noise and Air Quality 86

6.5.3 Other Socioeconomic Impacts 87

7.0 Risks, Risk Management and Mitigation 89

7.1 Project Alternatives 89

7.2 Management and Mitigation of Impacts 89

7.3 Review of Risks 90

7.4 Uncertainty and Significance of Potential Impacts 98

7.4.1 Significance of Potential Impacts 98

7.4.2 Uncertainty 98

8.0 References 99

Figures

Figure 1.1	Locality Plan	3
Figure 1.2	Key features of the MCCO Project	4
Figure 1.3	Proposed offset areas	6
Figure 2.1	Biophysical Strategic Agricultural Land and Critical Industry Clusters	9
Figure 3.1	Mean monthly rainfall and monthly rainfall for 2000 and 2006 for the BoM Scone SCS weather station (061089)	16
Figure 3.2	Mean temperatures, lowest and highest temperatures for the BoM Scone SCS weather station (061089)	16
Figure 3.3	Aerial image 1967	19
Figure 3.4	Soil Landscapes in the Project Locality	26
Figure 3.5	Land and Soil Capability Classes in the Project Locality	27
Figure 3.6	Soil and land resources in the project locality	28
Figure 3.7	Surface water in the locality and MCCO Additional Project Area	31
Figure 4.1	Vegetation communities in the MCCO Additional Project Area	38
Figure 4.2	Slope Analysis in the MCCO Additional Project Area	41
Figure 4.3	Soil types in the MCCO Additional Project Area	44
Figure 4.4	Re-classified Land Suitability Class in the MCCO Additional Project Area	47
Figure 4.5	Soil Landscapes in the proposed offset area	50
Figure 4.6	Land and Soil Capability Classes in the proposed offset areas	51
Figure 4.7	Soil and land resources in the proposed offset area	53
Figure 4.8	Mapped BSAL for the proposed offset sites	56
Figure 5.1	Land ownership	58
Figure 7.1	Agricultural Impacts Risk Ranking matrix (reproduced from OEH and OASFS, 2013)	91
Figure 7.2	Agricultural Impact Risk Ranking probability descriptors (reproduced from OEH and OASFS, 2013)	91

Plates

Plate 4.1	Loose surface rock in areas mapped as BSAL in Wybong Heights	55
Plate 5.1	Young, non-productive olive orchard in the MCCO Additional Project Area	61
Plate 5.2	Lucerne cropping at Dry Creek Road	63
Plate 5.3	Grazing along Dry Creek Road (foreground) and recently worked field in the background beyond Wybong Creek	64

Tables

Table 2.1	Overview of AIS Guidelines, SEARs and Where Addressed in AIS	11
Table 3.1	Soil landscapes, Great Soil Group, Australian Soil Classification and Land and Soil Capabilities in the locality	20
Table 3.2	Land and Soil Capability Classes (adapted from OEH, 2013) and area in the locality	22
Table 3.3	Summary of soil and land resource (SLR) units in the locality and limitations to land use practices (based on OEH, 2018).	29
Table 3.4	Native vegetation communities in the locality	34
Table 4.1	Soil landscapes in the proposed offset areas	49
Table 4.2	Land and soil capability classes and size in the proposed offset area	49

Table 4.3	Soil and land resource units (based on OEH, 2018) in the proposed offset areas	52
Table 5.1	Wybong land settlers' land use in 1885	59
Table 5.2	Land Use by Area for Agriculture in the Muswellbrook LGA, 2000-2001, 2005-2006, 2010-2011 and 2015-2016 data	65
Table 5.3	Estimated Value of Agricultural Products for Muswellbrook LGA, Hunter Valley (excl Newcastle) and New South Wales in 2015-2016	66
Table 5.4	Estimated gross value for agricultural commodities in Muswellbrook LGA and Hunter Valley excl. Newcastle in 2015-2016.	66
Table 5.5	Gross Value of selected agricultural commodities in the Muswellbrook LGA in 2005-2006, 2010-2011 and 2015-2016.	68
Table 5.6	Annual yield and livestock numbers in the Muswellbrook LGA in 2005-2006, 2010-2011 and 2015-2016.	68
Table 5.7	Numbers of horses in the Muswellbrook LGA, Hunter Valley and NSW in 2005/2006 and 2010/2011	71
Table 5.8	Farm demographics in the Muswellbrook LGA	73
Table 6.1	Change to agricultural resources and land use in the MCCO Additional Project Area (based on EMM, 2019)	78
Table 6.2	Soil Resources directly impacted within MCCO Additional Project Area	80
Table 7.1	Risk assessment for impacts to agriculture by the MCCO Project	92

Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
AIS	Agricultural Impact Statement
ASC	Australian Soil Classification
BoM	Bureau of Meteorology
BSAL	Biophysical Strategic Agricultural Land
CEC	Cation exchange capacity
CEEC	Critically Endangered Ecological Community
CICs	Critical Industry Clusters
Colinta	Colinta Pastoral Company
DPE	Department of Planning and Environment
DPI	Department of Primary Industries
EIS	Environmental Impact Statement
EMS	Environmental Management System
EP&A Act	Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ESP	Exchangeable Sodium percentage
ETL	Electricity Transmission Line
ha	Hectares
Interim Protocol	Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land
K	Potassium
km	Kilometre
LGA	Local Government Area
Locality	the area within a 5 km radius of the centre of the MCCO Additional Project Area
LSC	Land and Soil Capability

Abbreviation	Definition
m	Metre
Mangoola	Mangoola Coal Operations Pty Limited
mbgl	Metres below ground level
MCCO	Mangoola Coal Continued Operation
MCCO Project	Mangoola Coal Continued Operations Project
Mining SEPP	Mining, Petroleum Production and Extractive Industries
MOP	Mining Operations Plan
Mtpa	Million tonnes per annum
OEH	Office of Environment and Heritage
P	Phosphorous
PA	Project Approval
RBA	Reserve Bank of Australia
ROM	Run of mine
SEARs	Secretary's Environmental Assessment Requirements
SIA	Social Impact Assessment
SLR	Soil and land resource
SRLUP	Strategic Regional Land Use Plan
TDS	Total suspended solids
TEC	Threatened ecological community
Umwelt	Umwelt (Australia) Pty Limited

Executive summary

This Agricultural Impact Statement (AIS) was prepared to determine the potential impact of the Mangoola Coal Continued Operations (MCCO) Project on agricultural resources and agricultural enterprises.

The MCCO Project is located in Wybong, approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW. The MCCO Additional Project Area has a size of approximately 1,062 hectares (ha) with a proposed disturbance area of approximately 623 ha. With the exception of small sections of public road corridors and Crown land, Mangoola owns all land within the proposed MCCO Additional Project Area.

A detailed soil assessment, which was undertaken as part of the wider Environmental Impact Statement (EIS), showed that no Biophysical Strategic Agricultural Land (BSAL) is present in the MCCO Additional Project Area. The assessment also showed that the majority of the area has a Land and Soil Capability (LSC) Class of 5 or higher. Areas of LSC Class 4 and LSC Class 3 are also present in the MCCO Additional Project Area. The small extent of LSC Class 3 parcels may be prohibitive to more intense agricultural uses, such as cropping.

Based on the LSC Classes and fertility analysis of the local soil types, the MCCO Additional Project Area is not suited for high intensity agricultural uses such as cropping, but is able to sustain grazing if stocking rates take local limitations into consideration. The ephemeral Big Flat Creek, which traverses the MCCO Additional Project Area, has low value to agriculture due to its strong ephemeral nature and water quality that limits its use for stockwater.

Four biodiversity offset areas have been proposed as part of the MCCO Project, namely Wybong Heights, Mangoola, Highfields and Mangrove. The latter two are pre-existing offset areas proposed for the United Wambo Project and are therefore already committed to be removed from agricultural land uses. These two offset areas were assessed as part of the United Wambo Open Cut Coal Mine Project and as a result, they are not discussed further in this AIS. The area required for the proposed Wybong Heights and Mangoola offset sites is approximately 1,766 ha, which will be managed for biodiversity conservation.

The majority of land in the proposed offset areas has moderate to high limitations to cultivation. These areas are currently suitable for grazing operations. Approximately 215 ha, however, have moderate or fewer limitations to cultivation and cropping may be a viable option for some of these areas. A total of 148.1 ha of BSAL has been mapped under the Upper Hunter Strategic Regional Land Use Policy (SRLUP) regional mapping for the proposed offset areas.

The project locality used for this assessment (defined as the area within a 5 km radius of the centre of the MCCO Additional Project Area), has predominantly a LSC Class of 5, indicating high limitations to high impact agricultural land uses. Areas associated with the Wybong Creek floodplains however, have LSC Classes of 2 and 3 and thus are likely well suited for cropping. Approximately 434 ha of BSAL, as well as approximately 1,407 ha Equine and 862 ha of Viticulture Critical Industry Clusters (CICs) have been mapped under the Upper Hunter SRLUP for the locality. All of these areas fall outside of the MCCO Additional Project Area.

Wybong Creek, which flows through the locality from north to south, is an important agricultural water resource.

The MCCO Additional Project Area as well as the proposed Wybong Heights and Mangoola offset sites are currently used for cattle grazing. The land is owned by Mangoola/Glencore and management of the grazing

operation is carried out by Colinta Pty Ltd (Colinta), a wholly owned subsidiary of Glencore. There are no private landholders in the MCCO Additional Project Area or the proposed offset sites.

Cattle grazing is the dominant land use in the locality, both on improved pasture and native pasture. Some cropping is carried out on the floodplain of Wybong Creek. Despite being mapped as a Viticulture CIC, only one active vineyard is present in the locality. No horse studs are situated within the locality, however, one horse stud is located to the north-west and another to the south-west of the locality.

The total area of disturbance is forecasted to be 623 ha of which 612 ha will impact on agricultural land with the balance of land consisting of existing roads, house blocks and other built infrastructure not used for agriculture. The predicted post-mining LSC Classes are LSC Class 8 for the final void area, LSC Class 6 for rehabilitated overburden and areas disturbed by drainage management or powerlines will retain the pre-mining LSC class. The post-mining land use is native woodland areas for conservation and thus the area will be lost for agricultural use should the MCCO Project be approved.

For the proposed offset areas, the land will be required to be converted to biodiversity conservation. Mangoola has defined the proposed offset areas in consideration of achieving a balance between agricultural production and conservation with part of the properties retained for agriculture. While the land of the proposed offset areas will be lost for agriculture, there will be no negative impacts to the land itself which will retain its current agricultural capability.

The impacts of the proposed MCCO Project, including proposed offset areas, for agricultural enterprises in the MCCO Additional Project Area and proposed to offset area are low. Affected land is exclusively managed by Colinta and occurring impacts account for only a small component of Colinta's operations within NSW and Australia. The breeders run on the MCCO Additional Project Area (350 head), proposed Mangoola and Wybong Heights offset sites (150 and 60 heads, respectively) make up approximately 11% of the Colinta NSW cattle numbers and for just over 1% of the Colinta Australian herd. The impact to the local saleyards through the MCCO Project is considered negligible as for the worst case scenario, the reduction of cattle being sold at a saleyard is 1%.

Impacts to the agricultural resources and enterprises in the locality due to the MCCO Project are expected to be low. Modelled changes to Wybong Creek baseflow are very small and within natural variability and impacts to groundwater are mainly due to the existing approved Mangoola Coal Mine.

Seven properties have been predicted to exceed acquisition criteria due to noise. No impacts to the two horse studs (located outside of the locality) and the vineyard are expected. For the MCCO Project, impacts to visual amenity will be limited. Local topography largely screens the proposed operation from view of local residents. There will be only limited visibility of the MCCO Project along sections of Wybong Road and Ridgelands Road, particularly once rehabilitation is completed. Therefore the predicted visual impacts of the MCCO Project are not expected to impact on agricultural enterprises.

1.0 Introduction

Mangoola Coal Operations Pty Limited (Mangoola) has engaged Umwelt (Australia) Pty Limited (Umwelt) to complete an Agricultural Impact Statement (AIS) for the Mangoola Coal Continued Operations Project (MCCO Project). The purpose of the assessment is to address the requirements of the Secretary's Environmental Assessment Requirements (SEARs) relating to impacts of the MCCO Project on agricultural land, resources and land use on and in the vicinity of the MCCO Project Area. The AIS forms part of an Environmental Impact Statement (EIS) being prepared by Umwelt to accompany an application for development consent under Division 4.1 and 4.7 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the MCCO Project.

1.1 Project Overview

Mangoola Coal Mine is an open cut coal mine located approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman in the Upper Hunter Valley of NSW (refer **Figure 1.1**). Mangoola has operated the Mangoola Coal Mine in accordance with Project Approval (PA) 06_0014 since mining commenced at the site in September 2010.

The MCCO Project will allow for the continuation of mining at Mangoola Coal Mine into a new mining area to the immediate north of the existing operations. The MCCO Project will extend the life of the existing operation providing for ongoing employment opportunities for the Mangoola workforce. The MCCO Project Area includes the existing approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area as shown on **Figure 1.1**.

The MCCO Project generally comprises:

- open cut mining peaking at the same rate as that currently approved (13.5 Million tonnes per annum (Mtpa) of run of mine (ROM) coal) using truck and excavator mining methods
- continued operations within the existing Mangoola Coal Mine
- mining operations in a new mining area located north of the existing Mangoola Coal Mine, Wybong Road, south of Ridgelands Road and east of the 500 kV Electricity Transmission Line (ETL)
- construction of a haul road overpass over Big Flat Creek and Wybong Road to provide access from the existing mine to the proposed Additional Mining Area
- establishment of an out-of-pit overburden emplacement area
- distribution of overburden between the proposed Additional Mining Area and the existing mine in order to optimise the final landform design of the integrated operation
- realignment of a portion of Wybong Post Office Road
- the use of all existing or approved infrastructure and equipment for the Mangoola Coal Mine with some minor additions to the existing mobile equipment fleet
- construction of a water management system to manage sediment laden water runoff, divert clean water catchment, provide flood protection from Big Flat Creek and provide for reticulation of mine water. The water management system will be connected to that of the existing mine

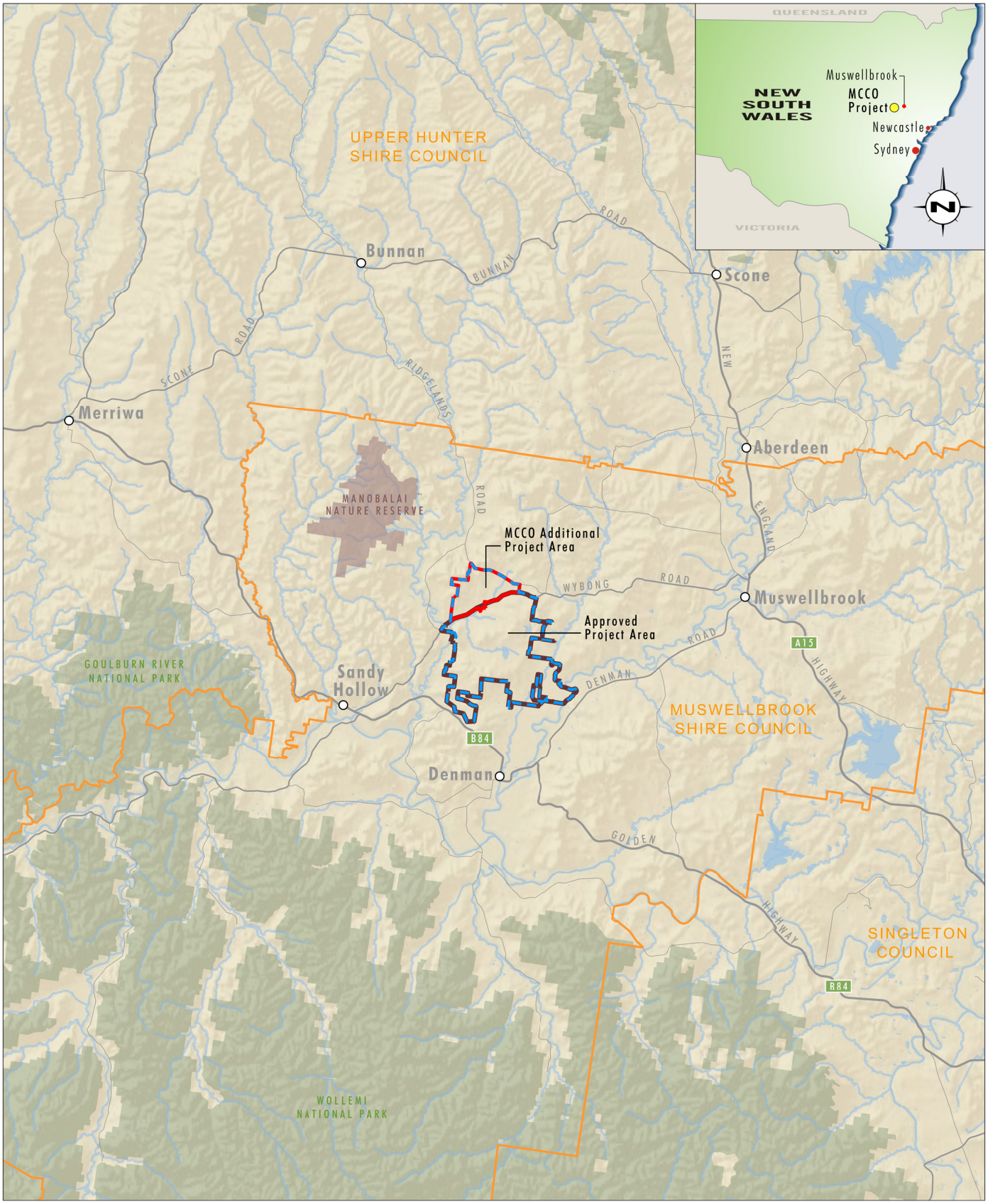
- continued ability to discharge excess water in accordance with the Hunter River Salinity Trading Scheme (HRSTS)
- establishment of a final landform in line with current design standards at Mangoola Coal Mine including use of natural landform design principles consistent with the existing site
- rehabilitation of the proposed Additional Mining Area using the same revegetation techniques as at the existing mine
- a likely construction workforce of approximately 145 persons. No change to the existing approved operational workforce
- continued use of the mine access for the existing operational mine and access to/from Wybong Road, Wybong Post Office Road and Ridgelands Road to the MCCO Project Area for construction, emergency services, ongoing operational environmental monitoring and property maintenance.

Figure 1.2 illustrates the key features of the MCCO Project.

This AIS provides an assessment of the potential impacts of the MCCO Project on the agricultural resources, agricultural industries and agricultural productivity of the MCCO Additional Project Area and the locality of the MCCO Project. The AIS has been undertaken in accordance with the SEARs and following relevant guidelines or policies, including the Strategic Regional Land Use Policy Guideline for Agricultural Impact Statements at the Exploration Stage (NSW Government, 2015) and the Agricultural Impact Statement Technical Notes (DPI, 2013a).

The AIS provides:

- information about current agricultural resources and agricultural production of the MCCO Additional Project Area and locality
- information about the potential impacts of the MCCO Project on the agricultural resources and enterprises in the MCCO Additional Project Area and locality
- an assessment of the significance of potential impacts, based on a risk assessment process
- proposed measures to mitigate and minimise any risks to agricultural resources and industries of the MCCO Additional Project Area and its locality.



Data Source: Glencore (2018), LPI (2016)

0 5 10 20km

1:400 000

Legend

- MCCO Project Area
- Approved Project Area
- MCCO Additional Project Area
- Local Government Area

FIGURE 1.1

Regional Locality Plan

File Name (A4): R16/4004_189.dgn
20181004 14.01

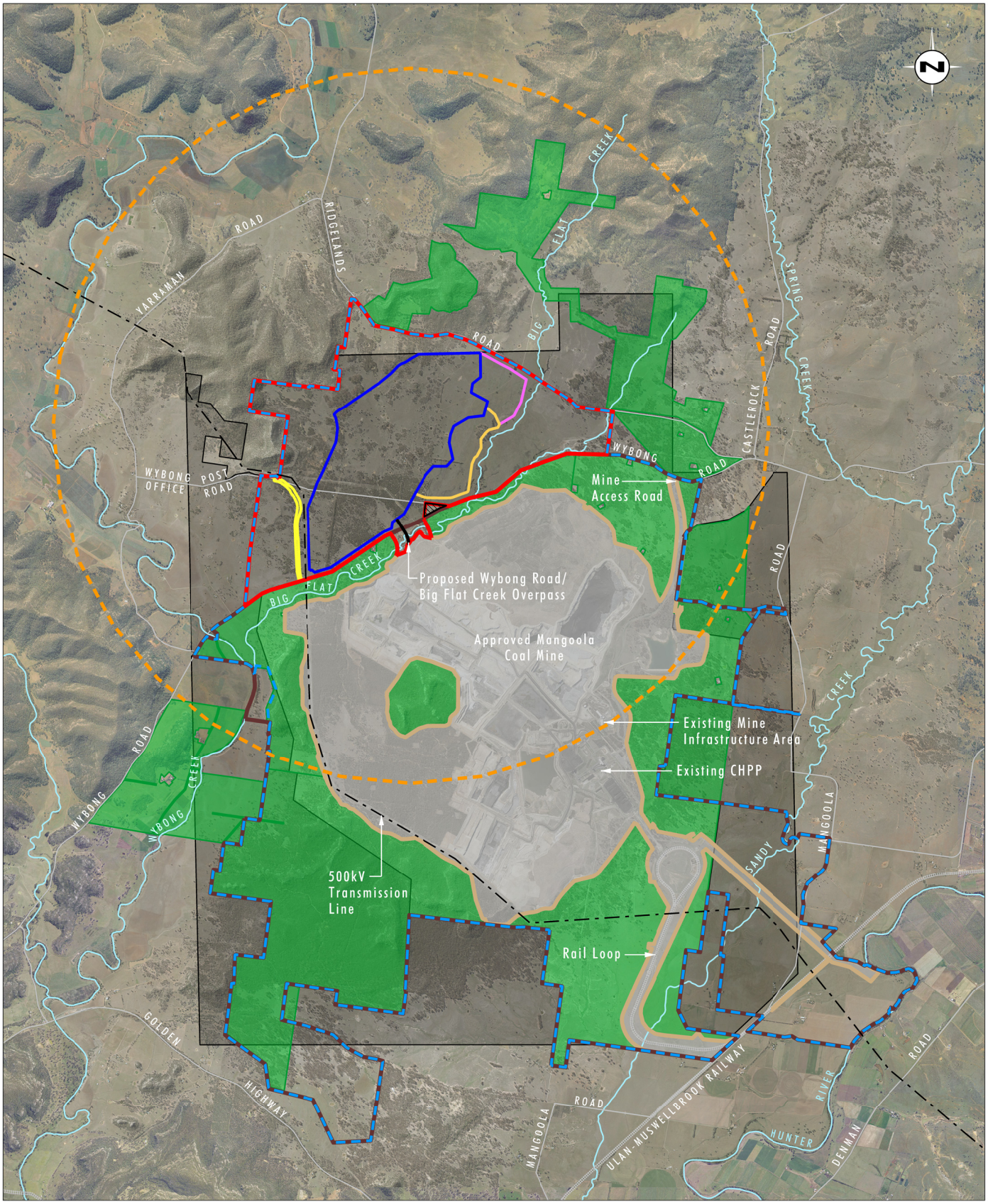


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 1.0 2.0 3.0km
1:75 000

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Proposed Additional Mining Area
- Proposed Emplacement Area
- Proposed Topsoil Stockpile Area
- Wybong Post Office Road Realignment
- Crown Land (TSR) Excluded from MCCO Project Area
- Project Locality
- Assessment Lease 9
- Existing Offsets

FIGURE 1.2

Key Features of the Mangoola Coal Continued Operations Project

File Name (A4): R11/4004_181.dgn
20190506 14.44

1.2 Project Area and Locality

This AIS assesses potential impacts of the MCCO Project to agriculture in a site specific and regional context. The MCCO Project Area includes the existing Approved Project Area for Mangoola Coal Mine and the MCCO Additional Project Area as shown on **Figure 1.2**. The Additional Project Area includes the proposed Additional Mining Area to the north of the existing mine. The areas discussed in the AIS are defined as follows.

MCCO Project Area

The MCCO Project Area refers to both the existing approved operation and the MCCO Additional Project Area (refer to **Figure 1.2**).

MCCO Additional Project Area

The MCCO Additional Project Area is shown in **Figure 1.2** and is located directly to the north of the existing Mangoola Coal Mine. The MCCO Additional Project Area comprises of 1,062 hectares (ha).

MCCO Additional Disturbance Area

The MCCO Additional Disturbance Area is located within the MCCO Additional Project Area and is approximately 623 ha. The MCCO Additional Disturbance Area will include the establishment of required infrastructure, mining operations, realignment of Wybong Post Office Road and realignments to existing powerlines and infrastructure as required.

Proposed Offset Sites

There are four proposed offset sites being Wybong Heights, Mangoola, Highfields and Mangrove (refer to **Figure 1.3**). These two offset areas were assessed as part of the United Wambo Open Cut Coal Mine Project and are already committed as offset areas proposed for the United Wambo Project. They are therefore already committed to be removed from agricultural land uses and there is no impact on agriculture related to these properties as a result of the MCCO Project. As a result, the proposed Highfields and Mangrove offset sites do not require further consideration in this AIS.

The proposed Wybong Heights offset property is approximately 889 ha of which 761 ha is proposed to be removed from agricultural production for use as offset lands. The proposed Mangoola offset site consists of areas of land located within and surrounding the MCCO Additional Project Area. The proposed Mangoola offset area is approximately 1,005 ha, with approximately 810 ha located outside and approximately 195 ha within the MCCO Additional Project Area.

Locality

The Agricultural Impact Statement Technical Notes (DPI, 2013a) define locality as the area of the parish or an appropriate proportional area of the parish if the project area is on the edge of a parish (DPI, 2013a). The MCCO Additional Project Area is located on the northern boundary of the Wybong Parish. The Wybong Parish has a maximum width and length of approximately 10 km. Based on this, the locality in this AIS refers to a circle with a 10 km diameter through the centre of the MCCO Additional Project Area (**Figure 1.2**).

Region

The MCCO Additional Project Area is located in the Muswellbrook Local Government Area (LGA) in the Upper Hunter Valley Region of NSW.

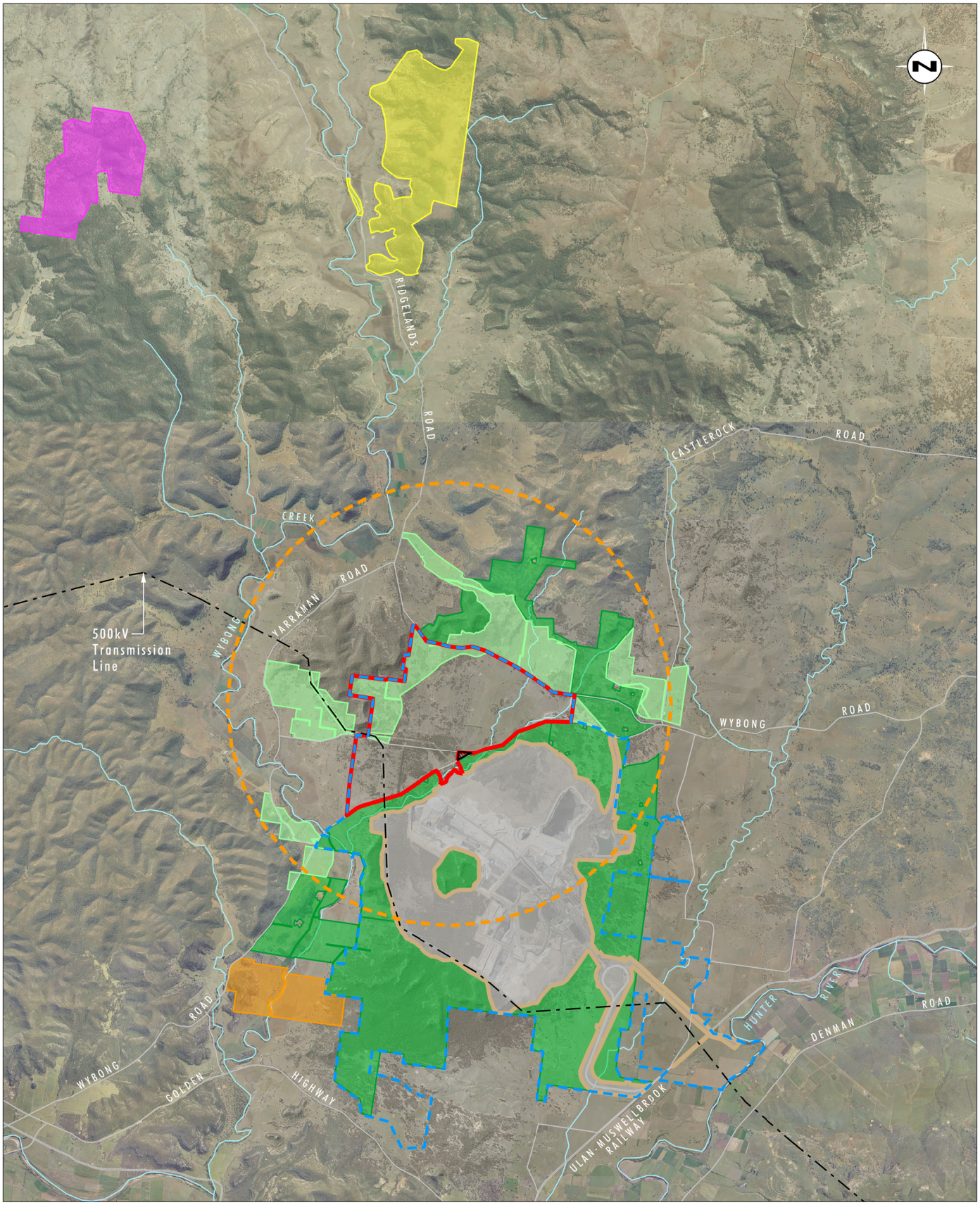


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 2.0 4.0 6.0km
1:120 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Crown Land (TSR) Excluded from MCCO Project Area
- Project Locality
- Existing Offsets
- Proposed Mangoola Offset Sites
- Proposed Mangrove BioBank Sites
- Proposed Wybong Heights Offset Site
- Proposed Highfields BioBank Site

FIGURE 1.3

Proposed Offset Areas

File Name (A4): R11/4004_248.dgn
20190506 14.54

1.3 Report Structure

Section 1.0 describes the MCCO Project and the general approach to the scope of the assessment.

Section 2.0 provides an overview of the NSW AIS requirements, aims and objectives of the assessment, as well as the scope, scale and method of the assessment.

Section 3.0 provides information about the agricultural resources of the locality of the MCCO Project predominantly based on publically available information.

Section 4.0 provides information regarding the agricultural resources of the MCCO Additional Project Area and the proposed biodiversity offset areas. This section includes mapping of land and soil characteristics including biophysical strategic agricultural land (BSAL). Further, site specific details on slope and land characteristics, soil types and land and soil capability are presented.

Section 5.0 provides an outline of the agricultural enterprises and infrastructure of the MCCO Additional Project Area, the locality and the regional context. This includes estimated production values, historical agricultural enterprises, strategic rural land, and current agricultural uses and enterprises.

Section 6.0 provides an assessment of the level of impact the MCCO Project may have on agricultural resources and enterprises. Permanent and temporary impacts are identified for the MCCO Additional Project Area and its locality.

Section 7.0 presents project alternatives taken into consideration. This section evaluates the extent of the potential impacts using a risk assessment process. The risk assessment incorporates information about existing agricultural resources, the production and productivity of existing enterprises and proposed post mining landforms, soils, water resources and land uses. Mitigation measures are proposed to reduce the risk of impact on agricultural resources and enterprises.

2.0 Assessment Requirements, Project Scope and Approach

The agricultural impact assessment requirements include the SEARs (**Section 2.1**), the Upper Hunter Strategic Regional Land Use Plan (Department of Planning and Infrastructure, 2012) (**Section 2.2**) and the State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP) (**Section 2.3**). The Agricultural Impact Statement Technical Notes (DPI, 2013a) has also been adhered to. **Section 2.4** provides details of the requirements of the technical notes and where relevant information can be found in this report.

This AIS has been prepared in accordance with the requirements and guidelines outlined in this Chapter.

2.1 Secretary's Environmental Assessment Requirements

The Department of Planning and Environment (DPE) issued the SEARs for the MCCO Project on 15 February 2019 (replacing a previous version of the SEARs issued on 22 August 2017). The SEARs outline the specific requirements for the MCCO Project EIS, including the assessment of impacts on strategic agricultural land and the need to prepare the AIS. **Table 2.1** shows the SEARs requirements and relevant sections of the AIS.

2.2 Upper Hunter Strategic Regional Land Use Plan

The MCCO Project is located in the area covered by the Upper Hunter Strategic Regional Land Use Plan (Upper Hunter SRLUP). This plan identifies land which is of strategic importance for agriculture, either due to its land capability or other economic and social value (DPI, 2012).

Mapping of this high quality land has been undertaken on a regional scale. BSAL mapping is based on available land and soil characteristics. Critical Industry Clusters (CICs), such as Viticulture CICs or Equine CICs, are intended to be based on specific production and economic values.

BSAL is defined as land with Land and Soil Capability (LSC) Classes 1 or 2 and a moderate to high soil fertility. Land with a LSC Class 3 and moderately high to high soil fertility may also qualify as BSAL. Further, access to quality agricultural water supply is also a requirement.

CICs are a concentration of industries based on an agricultural product. The Upper Hunter SRLUP identifies that these productive industries are interrelated and are identified by a unique combination of factors such as location, infrastructure, heritage and natural resources. It also identifies that the industry clusters are of national and/or international importance, or are an iconic industry for a region's identity.

The locations of BSAL and CICs as mapped by the SRLUP in the locality are shown in **Figure 2.1**. Due to this regional scale mapping, BSAL verification is required to be carried out on a property scale (OEH and OASFS, 2013). A detailed soil survey has been carried out as part of this EIS and confirmed that no BSAL is present in the MCCO Additional Project Area (see **Section 4.4.1.5**).

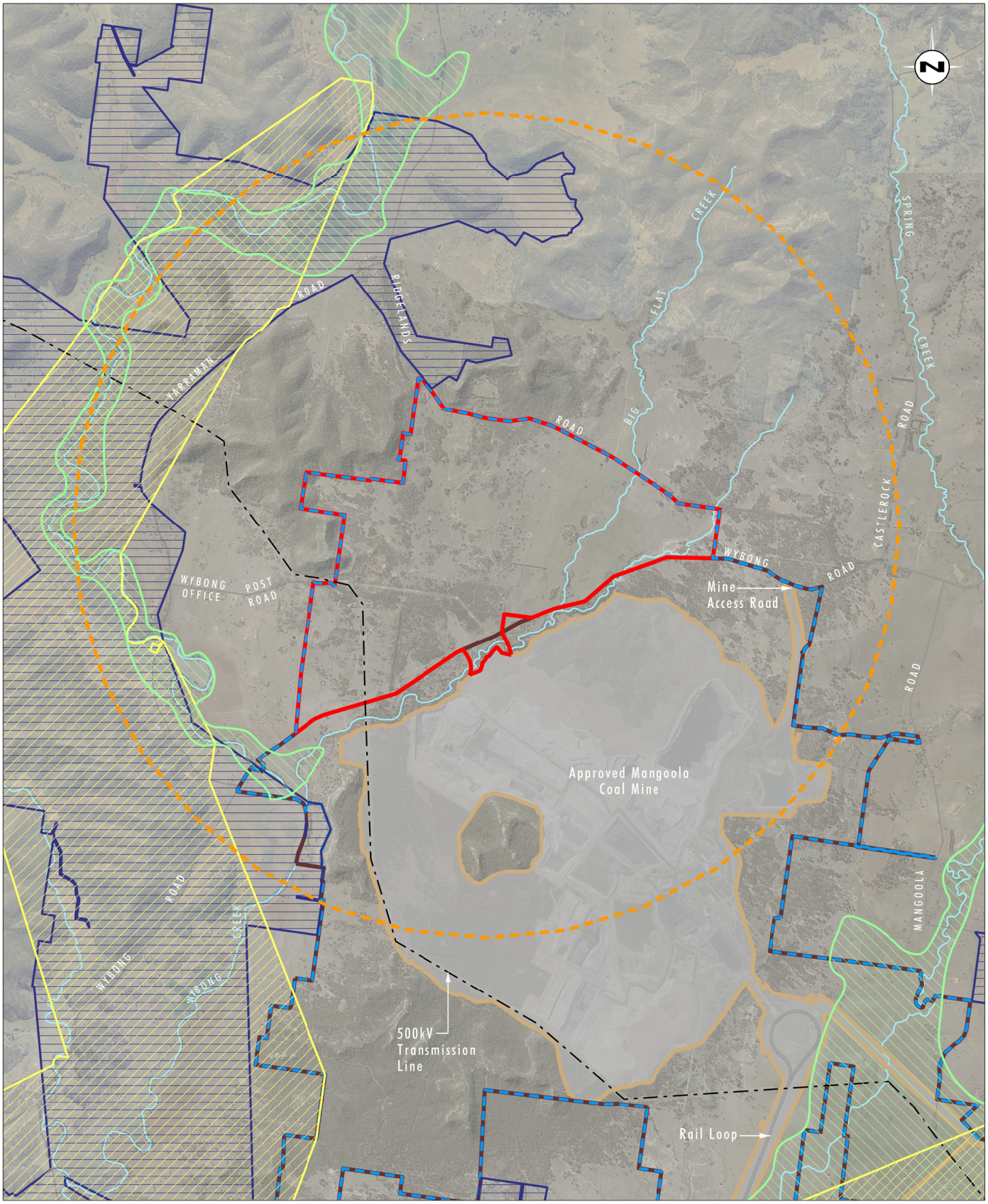


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

0 1.0 2.0 3.0km
1:65 000

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality

Strategic Regional Land Use Policy (SRLUP):

- Equine Critical Industry Cluster
- Viticulture Critical Industry Cluster
- Biophysical Strategic Agricultural Land

FIGURE 2.1

Biophysical Strategic Agricultural Land and Critical Industry Clusters

File Name (A4): R11/4004_182.dgn
20190506 14.57

The AIS is required to assess the potential impact of the MCCO Project on:

- agricultural land mapped as BSAL or land which a detailed soil survey identifies as BSAL within the MCCO Additional Project Area or in close proximity of this. As noted above, there is no BSAL within the MCCO Additional Project Area, with the closest BSAL mapped approximately 300 m from the MCCO Additional Project Area boundary
- agricultural resources of the proposed disturbance footprint and the surrounding locality. Agricultural resources are defined as land characteristics on which agriculture is dependent. This includes land and soil capability and soil fertility, quality, quantity and reliability of a water resource linked to the land (DPI, 2013a)
- other agricultural land uses and infrastructure, within or in close proximity to the MCCO Additional Project Area, or where relevant, more broadly in the region.

2.3 Mining SEPP

The Mining SEPP requires certain types of development to verify whether BSAL is present on a proposed site and whether the Gateway Process applies to the development application. The Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land (OEH and OASFS, 2013) (Interim Protocol) requires that BSAL mapping is verified for land within the proposed development area. The verification of BSAL within the MCCO Additional Project Area has been undertaken as part of the detailed soil assessment (included as an appendix of the EIS) and confirms that there is no BSAL in the MCCO Additional Project area. Subsequently a Site Verification Certificate was issued by DPE on 10 December 2018 confirming the absence of BSAL, therefore the MCCO Project is not subject to the gateway process.

BSAL has been mapped in close proximity to the MCCO Additional Project Area (within 300 m of the MCCO Additional Project Area boundary). While no on the ground verification of these areas has been undertaken, a review of aerial imagery shows that the majority of mapped BSAL is currently or has previously been used as cropping land. As the BSAL is located outside of the MCCO Additional Project Area, no direct impact on this land will occur. Indirect impacts are discussed in **Section 6.0**.

2.4 Requirements of the Agricultural Impact Statement Technical Notes

Relevant requirements of the technical notes are summarised in **Table 2.1**. The table further outlines the requirements of the SEARs and the relevant sections of this document where the required information from both the technical notes and the SEARs is provided.

Table 2.1 Overview of AIS Guidelines, SEARs and Where Addressed in AIS

Section of AIS Technical Notes	AIS Technical Notes Assessment Requirements	SEARs	Relevant Section of this AIS
1.0	Project overview • Overview of the project and project description	-	**1.1, 1.2**
2.1, 2.2	Assessment of agricultural resources in the project area • Detailed soil assessment and description • Slope and land characteristics identifying agricultural land suitability and land capability classes of the pre-mining landscape	-	**4.2, 4.3, 4.4,**
3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.1.7	Agricultural resources within locality • Soil characteristics including soil types and depths • Topography • Water resources and extraction location • Vegetation • Climate and climate variability	-	**3.0**
2.3, 3.1.3, 3.1.5,3.2	Agricultural land use and production • History of agriculture in the project area for a minimum of 10 years and correlation between history and climatic background. • Management practices of agricultural enterprises in the project area • Agriculture support infrastructure in the locality. • Location and type of agricultural industry in the locality. • Agricultural enterprises in locality.	-	**5.0**

Section of AIS Technical Notes	AIS Technical Notes Assessment Requirements	SEARs	Relevant Section of this AIS
2.4, 2.5, 2.6, 2.7, 4.1, 4.2, 4.3	Impact assessment • Land to be temporarily removed from agriculture, including the agricultural usage of the land, agricultural suitability and LSC. • Land to be returned to agriculture post mining, including LCS, evidence of feasibility, management requirements and land use type. • Land that will be permanently removed from agriculture (including offset sites), including expected decrease in LSC. • Agriculture undertaken on buffer or offset zones during life of project • Impacts on agricultural resources • Assessment of impacts on water availability and water movement • Assessment of socio-economic impacts	• An assessment of the likely impacts of the development on the soils and land capability of the site and surrounds, paying particular attention to any strategic agricultural land • An assessment of the agricultural impacts of the development An assessment of the compatibility of the development with other land uses in the vicinity of the development, in accordance with the requirements of Clause 12 of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*, paying particular attention to agricultural land uses in the region	**6.0**
5.1-5.6	Mitigation and management • Project justification • Project alternatives • Monitoring programs to assess predicted versus actual impacts • Trigger response plans and actions taken if required • Appropriateness of remedial actions to address and respond to impacts • Discussion of capacity of rehabilitated land for the intended final land use • Planning for progressive rehabilitation	-	**7.0**
6.0	Consultation	-	**2.5.2**

2.5 Method of Assessment

This section discusses the method of assessment used to prepare the AIS. As the impacts associated with the Mangoola Coal Mine within the Approved Project Area have previously been assessed and approved they have not been considered as a part of this impact assessment. In this regard the AIS has focused on the proposed mining operations within the MCCO Additional Project Area.

In order to assess the potential impacts to agricultural resources within the MCCO Additional Project Area the AIS has relied on information provided within the detailed technical studies (detailed below), which assess the potential impacts related to the MCCO Project. The AIS has also considered the potential impacts of changing the land use of the proposed biodiversity offset areas (as proposed to offset impacts identified by the Biodiversity Assessment Report) from agriculture to conservation. Potential impacts on agricultural resources within the MCCO Project locality have been assessed based on the review of publicly available information, such as information from Bureau of Meteorology (BoM), the Australian Bureau of Statistics (ABS) and Office of Environment and Heritage (OEH) eSPADE website.

2.5.1 Review of other Biophysical, Social and Economic Studies as they relate to Agriculture

Productive and sustainable agriculture depends on the interaction of the natural resources of the land, the history of land use and the availability of suitable infrastructure, skills, investment and market access. The AIS therefore integrates, analyses and interprets outcomes from multiple, detailed technical reports which have been prepared for the MCCO Project EIS to understand the natural resources that support agriculture, local, regional agricultural productivity and the local agricultural community. The analysis investigates the relative importance of factors influencing and impacting on the resilience of these agricultural resources, production and communities. The reviewed technical studies are:

- Social Impact Assessment (SIA)
- Soils Assessment (including Biophysical Strategic Agricultural Land Assessment)
- Surface Water Assessment
- Groundwater Assessment
- Historic Heritage Assessment
- Biodiversity Assessment (including biodiversity offset strategy)
- Rehabilitation strategy
- Noise Assessment
- Air quality Assessment
- Blast Impact Assessment.

2.5.2 Consultation

Extensive community consultation was carried out as part of the preparation of the EIS. This included project related consultation with a wide range of stakeholders as well as consultation as part of the SIA program (refer to the main text of the EIS for further information). Consultation was undertaken using a range of mechanisms which included meetings, presentations, open days, newsletters, face to face

interviews, phone discussions and other forms of personal communication (e.g. emails). Relevant findings from the stakeholder consultation undertaken for the MCCO Project were considered in the preparation of this AIS.

In addition to the SIA, multiple phone interviews with the relevant Colinta land managers were undertaken. These interviews provided an understanding of the agricultural land use practices for the MCCO Additional Project Area and proposed Mangoola and Wybong Heights offset sites. The collected data has informed **Sections 5.3.1**, **5.3.2**, **6.4** and **6.5.3.1** and included:

- primary land use
- approximate heard size (currently and non-drought years) of the MCCO Additional Project Area, whole of Mangoola owned grazing land, proposed offset areas, properties of the proposed offset areas
- cattle market (feedlot, saleyard)
- requirement of hand feeding size (currently and non-drought years)
- quality of the land compared for land use
- water sources used
- any land management practices.

3.0 Agricultural Resources of the Locality

The following section discusses the agricultural resources in the locality as defined in **Section 1.2** and shown in **Figure 1.2**. The data used in this section has been sourced from publically available information.

3.1 Climate

The locality is situated in humid subtropical climate (Cfa) in the Koeppen and Geiger Classification system. Cfa is characterised by a temperate climate (C), without a dry seasons (f) and hot summers (a) (Peel et al, 2007). The Scone SCS BoM weather station (Site number 061089), which was opened in 1950 and is still active[1] has been used as it provides a comprehensive set of data for the locality. It is located approximately 30 km to the east of the locality.

The mean annual rainfall for this station is 636.0 mm/year. Since opening of the Scone SCS weather station, the wettest year on record was 1950 with 1054.0 mm/year occurring, while the driest year was 2006 with, recording 319.2 mm/year. In the last 18 years, annual rainfall varied from a minimum of 319.2 mm in 2006 to a maximum of 812.8 mm in 2000.

Rainfall occurs throughout the year with an increase of recorded rainfall during the late spring and summer months (October to February). Lowest mean monthly rainfall occurs in July and August (35.8 mm and 38.2 mm, respectively), while highest monthly precipitation falls in January (81.8 mm) (**Figure 3.1**). **Figure 3.1** also shows that while rainfall on average follows a clear annual pattern, on a year to year basis monthly rainfall throughout the year can vary substantially.

Mean number of days per month show little variation throughout the year, with just over 6 days of rain occurring in April and just over 9 days of rain in June. As a result of the slightly higher occurrence of rain days in winter and the lower mean monthly rainfall amount in those month, rainfall intensities are higher during summer.

Over the last two years (2017 and 2018), the area has experienced ongoing dry conditions with recorded annual rainfall of 360.3 mm and 362.7 mm in 2017 and 2018, respectively[2]. The locality was declared to be in drought in March 2018[3].

[1] http://www.bom.gov.au/climate/averages/tables/cw_061089.shtml, accessed 01/02/2019

[2] http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=2018&p_c=-746371315&p_stn_num=061089, accessed 01/02/2019

[3] https://www.dpi.nsw.gov.au/climate-and-emergencies/droughthub/information-and-resources/seasonal-conditions/ssu/march-2018, accessed 01/02/2019

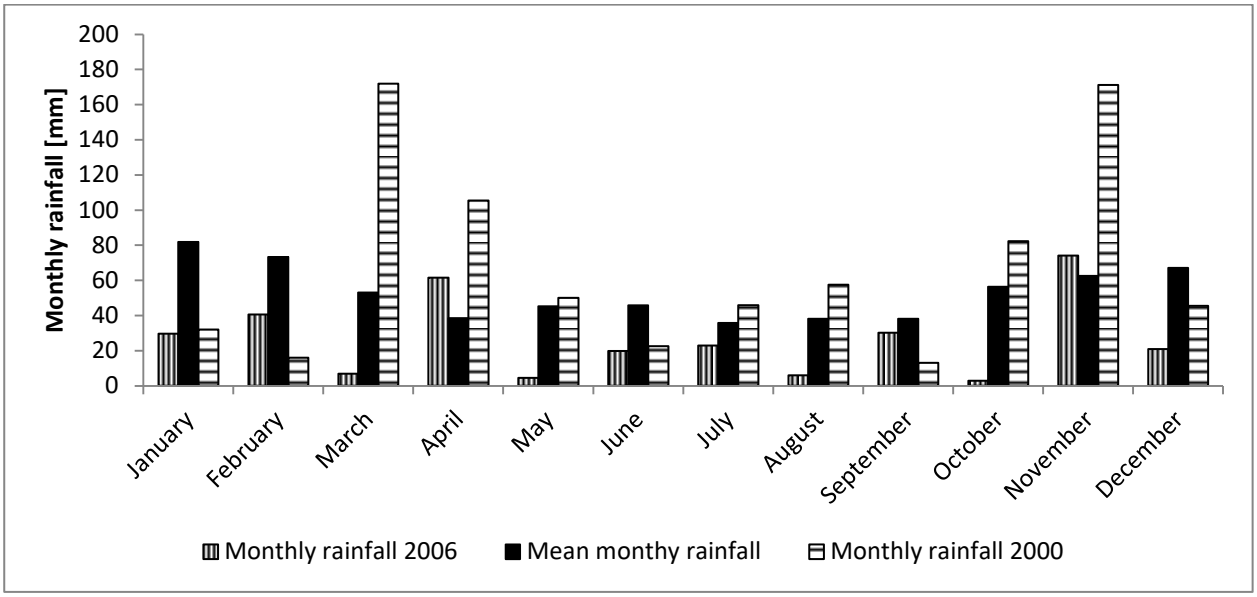


Figure 3.1 Mean monthly rainfall and monthly rainfall for 2000 and 2006 for the BoM Scone SCS weather station (061089)

Mean maximum temperatures range from 31.4°C in January to 16.5°C in July. Highest recorded temperature was 46°C in February 2017 (**Figure 3.2**). Mean number of days above 35°C in each summer month are between 3.9 days (February) and 6.3 days (January). Mean minimum temperatures range from 4.7°C in July to 17.0°C in January (**Figure 3.2**). The mean number of days below 0°C per months in winter ranged from 0.9 days in June to 2.1 days in July.

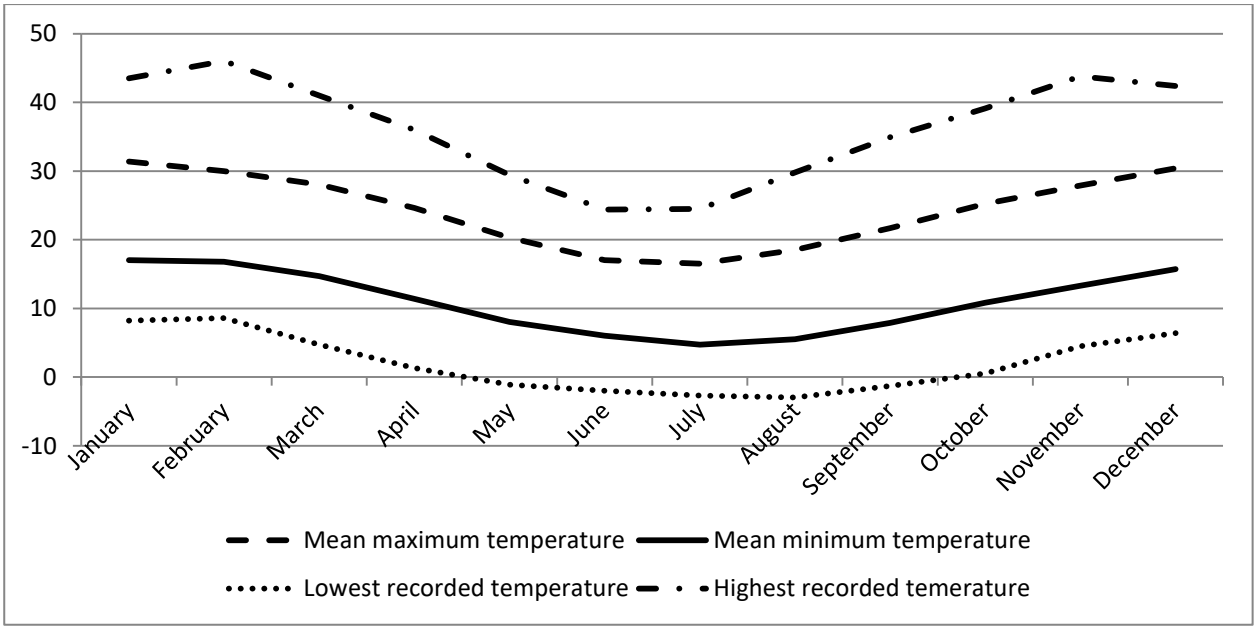


Figure 3.2 Mean temperatures, lowest and highest temperatures for the BoM Scone SCS weather station (061089)

3.1.1 Potential Impact of Climate Change

Generally, change in climate has the potential to have a negative impact on agriculture for example due to a reduction of precipitation during the growing season, increase in precipitation outside of the growing season, risk of flooding, increase in temperature extremes causing frost damage to crops and/or heat stress for crops and livestock.

OEH/Adapt NSW has prepared regional scale climate projections for NSW, for the near future (to 2030) and far future (2070). Annual mean maximum temperatures for the Hunter Region are projected to increase by 0.7°C in the near future and 2.0°C in the far future. In the Muswellbrook area temperatures in the far future may increase by as much as 3.0°C. Annual mean minimum temperatures are modelled to increase by 0.1°C and 2.1°C in the near and far future, respectively. As a result, the numbers of cold nights are expected to decrease, whereas hot days are anticipated to increase. In the Upper Hunter Valley hot days (>35°C) are projected to increase by 5-10 days in the near future and over 20 additional days in the far future (OEH, 2014).

The decrease of frost nights reduces the risk of crop loss during the growing season but at the same time may increase the abundance of pests due to the absence of frost induced reduction of pest populations. An increase of days exceeding 35°C may negatively impact livestock performance due to heat stress or increase costs of livestock farming to counteract heat stress.

Rainfall in the Hunter region, especially inland, is highly variable year on year, as well as varying between seasons. The Climate Snapshot for the Hunter (OEH, 2014) reports that most models project that average autumn rainfall will increase both by 2030 and by 2070, by as much as 20 to 30%. Spring and winter rainfall, however, is expected to decrease in the near future and no conclusive results could be drawn from far future spring rainfall modelling (OEH, 2014).

The reduction of spring precipitation may decrease the crop yield in the summer growing season due to lower plant available water in the soil, as well as less water being able to be collected in dams for irrigation purposes. Increase in autumn precipitation in combination with an increase of minimum temperatures may lead to an extension of the growing season. The 2014 Snapshot does not discuss rainfall intensity and the potential implications for the risk of flooding and flash flooding impacts on agricultural production.

By 2030, severe fire weather is projected to increase in summer, with little change occurring during spring and winter and a slight decline of fire risk is predicted in autumn. In the far future (2070), severe fire weather is thought to further worsen. Increases are predicted for summer, winter and spring. Autumn fire risk may decrease due to projected increases of autumn rainfall.

The predicted higher fire risk in summer, especially, indicates a higher likelihood that grassland and cropped land for livestock feed could be damaged.

3.2 Topography

The topography of the locality consists of a combination of rolling hills and floodplains. The latter are associated with Wybong Creek, at the western extent of the locality, and Big Flat Creek, near the MCCO Additional Project Area.

Rolling hills, with a maximum elevation of approximately 360 mAHD, are located to the north east and north west of the MCCO Additional Project Area. The hills are characterised by short and steep upper and mid-slopes and long and gentle footslopes flowing to Wybong Creek and Big Flat Creek. A further suite of rolling hills is located to the west of Wybong Creek, outside of the locality.

Mangoola Coal Mine is situated in the south eastern extent of the locality. Rolling hills with steep upper slopes are located to the west of the existing operation, before being dissected by Wybong Creek in the south western extent of the locality.

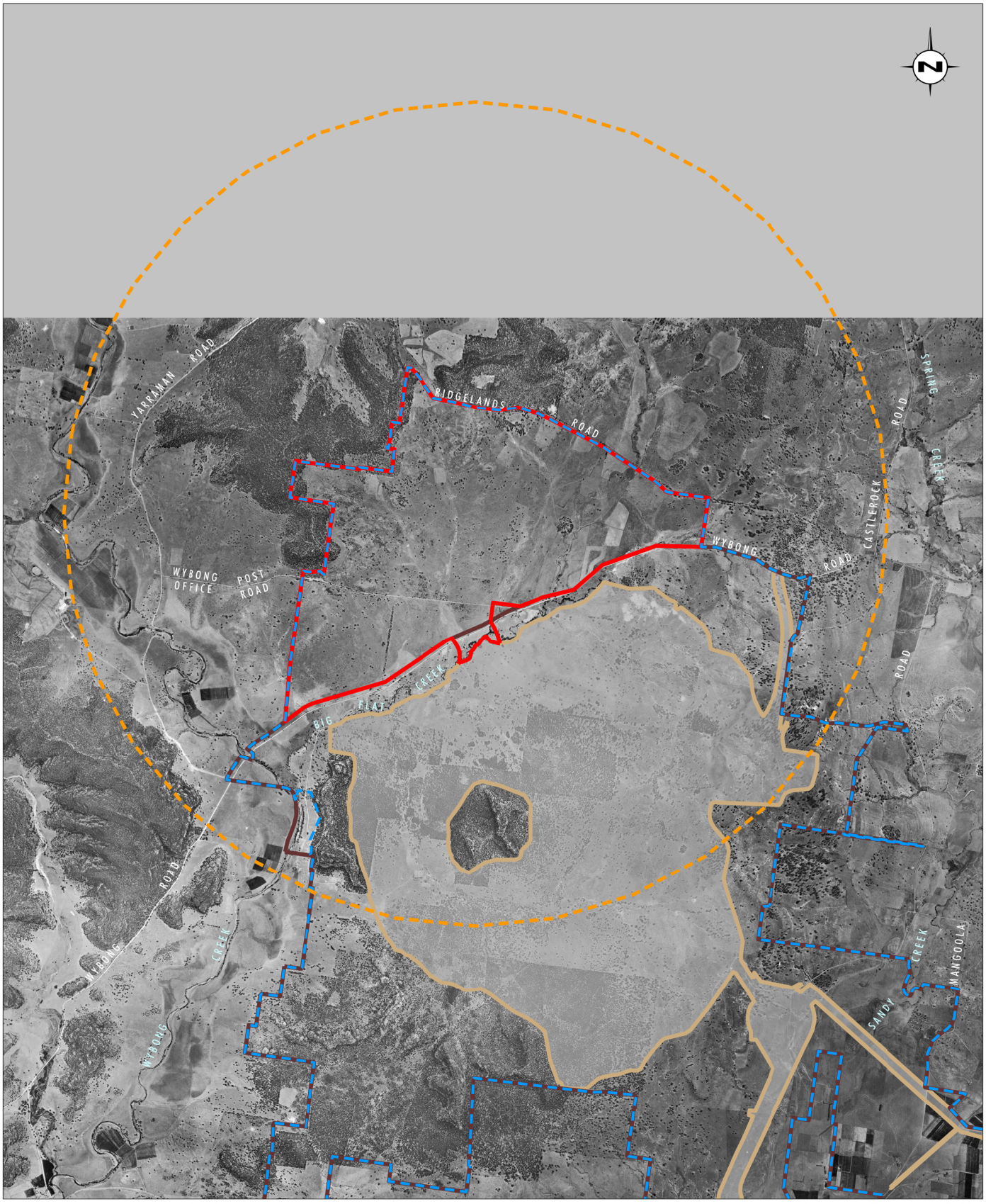
The floodplains as well as the gently inclined footslopes have been extensively cleared since 1930. **Figure 3.3** shows the extent of clearing in 1967. Limited clearing has taken place on the steep mid- and upper slopes. These slopes have poor land and soil capability classifications and soils, erodible soils, steep slopes and high erosion hazard. They are generally not suitable for agriculture and therefore not cleared (refer to **Section 3.3**).

3.3 Soils

The description of the soil landscapes and soil properties of the locality is based on mapping as shown in eSpade[4]. A summary of this is provided in **Table 3.1**. A comprehensive soils assessment has been undertaken for the MCCO Project by EMM (2019) with a summary of the key findings as relevant to the AIS provided in **Section 4.4.1**.

Soil landscape mapping was undertaken by the Soil Conservation Service of NSW and the locality is situated in the 1:250 000 Singleton mapping area (Kovac and Lawrie, 1991). Further, Australian Soil Classification (ASC) soil mapping (1: 250 000 scale), based on Land and Soil Capability (LSC) Class mapping, for the whole of NSW was undertaken by OEH (OEH, 2012a, OEH, 2013).

[4] http://www.environment.nsw.gov.au/eSpade2WebApp, accessed 16/11/2017



Data Source: Glencore (2019)

0 1.0 2.0 3.0km
1:65 000

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality
- No Aerial Image

FIGURE 3.3

1967 Aerial Image

Table 3.1 Soil landscapes, Great Soil Group, Australian Soil Classification and Land and Soil Capabilities in the locality

Soil landscape[1]	Landscape context[1]	Great Soil Group[1]	Limitations of soil landscape[1]	Australian Soil Classification[2]	Land and Soil Capability Class[3]
Wappinguy (wp)	Rolling low hills with some rocky sandstone knolls, hills, cuestas and benches. Slopes are <15%	Soils associated with Sandstones are predominantly Solodic Soils. Siliceous and Earthy Sands and rock outcrops, Brown Clays can occur on midslopes. Red-Earth-Euchrozem intergrades, Euchrozems, Prairie Soils, Alluvial Loams and Black Earths are associated with Basaltic Collovium.	• moderate to high erosion hazard • structural degradation hazard • low mass movement hazard • shallow soil depth • rock outcrops	Sodosol	Class 5
Lees Pinch (lp)	Rolling to steep hills with large sandstone outcrops, irregular benches and boulder littered slopes. Slopes range from 30-90%	Main soils are shallow Siliceous Sands with shallow Loams on finer textured rocks. Yellow and Grey Soloths occur on midslopes and Yellow and Brown Earths on footslopes.	• high mass movement hazard • moderate to high erosion hazard • rock outcrop • low fertility • high structural degradation hazard	Rudosol and Tenosol	Class 7
Merriwa (mw)	Terrace with gently undulating rises and slopes <3%.	Alluvial Soils occur on alluvial flats, Chermozems are the dominant soils on 1st river terrace and Black Earths on the 2nd terrace. Further minor soil types are Grey Clays in open depressions of tributaries, Brown Clays on 2nd terrace, Alluvial Soils in stream bank and Prairie Soils on lower slopes.	• some stream bank erosion • moderate to high flood hazard on alluvial flats	Vertosol	Class 2

Soil landscape[1]	Landscape context[1]	Great Soil Group[1]	Limitations of soil landscape[1]	Australian Soil Classification[2]	Land and Soil Capability Class[3]
Sandy Hollow (sy)	Undulating rises with smooth slope of <10%. Some sandstone outcrops and narrow flat benches with broken scarps	Yellow Solodic Soils on upper, mid- and lower slopes are the dominant soils. Some Red Earths occurring on midslopes below sandstone benches. Minor occurrences of Red Solodic Soils, Brown Solodic Soils and Siliceous Sands on lower slopes.	• moderate to very high erosion hazard • high soil salinity • low fertility • rock outcrops • moderate to high structural degradation hazard	Sodosol	Class 5
Castle Rock (cr)	Undulating low hills and footslopes. Slopes between 1-5%	Yellow Solodic Soils (dominant) on upper slopes with some Black Solodic Soils on flats and Alluvial Soils in drainage lines.	• high soil salinity • moderate to very high erosion hazard • low fertility	Sodosol	Class 5
Wollombi (wo)	Valley flats and undulating rises of low relief. Slopes are up to 3%	Alluvial Soils	• low fertility • high flood hazard • moderate stream bank erosion	Rudosol (Alluvial)	Class 3

[1]Kovac and Lawrie, 1991, [2]OEH, 2012a, [3]OEH, 2013

The LSC mapping of NSW is based on the rural land capability classification and mapping by the former Soil Conservation Service of NSW (Emery, 1986). However, it has an emphasis on a broader range of soil and landscape properties (OEH, 2012b). The LSC classes in the locality are shown in **Table 3.2**.

Table 3.2 Land and Soil Capability Classes (adapted from OEH, 2013) and area in the locality

Land and Soil Capability Class	LSC Definition	Area in Locality (ha)
1	Extremely high capability land: Land has no limitations and is capable of all rural land uses and land management practices. No special land management practices required.	0
2	Very high capability land: Land has slight limitations and is capable of most land uses and land management practices. Limitations can be managed by easily implemented management practices.	434.2
3	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, if more intensive and widely accepted management practices are in place. Careful management of limitations is required for cropping and intensive grazing to avoid degradation.	52.4
4	Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. Limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.	0
5	Moderate–low capability land: Land has high limitations for high-impact land uses. Land use is restricted to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	5,967.5
6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	0
7	Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.	1,349.4
8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.	0

The majority of the land in the locality has LSC classes 5 and 7 and has therefore severe to extremely severe limitations for land uses. Class 7 land falls into the Lees Pinch soil landscape and is associated with the steep and rocky hills (**Figure 3.4, Figure 3.5**). This soil landscape is currently forested and not used for any agricultural purposes. Clearing of the Class 7 LSC land could result in extensive erosion and thus be unwise.

Class 5 land occurs on mid- to lower slopes of the rolling hills, namely the Sandy Hollow, Wappinguy and Castle Rock soil landscapes (**Figure 3.4, Figure 3.5**). These areas have been extensively cleared and are predominantly used for grazing purposes. Due to the limitations of the Class 5 LSC areas, high intensity grazing is not sustainable and will cause gully erosion. Further, the long term grazing of Class 5 country is likely to have resulted in varying degrees of loss of fertile topsoil due to sheet erosion. This is a common occurrence of grazed Sodosols throughout the Hunter Valley and Australia.

Only areas associated with the Wybong Creek floodplain have the capability to sustain high impact agricultural land uses, thus with slight but significant limitations (LSC Class 2, Merriwa soil landscape) or moderate limitations (LSC Class 3, Wollombi soil landscape) (**Figure 3.4, Figure 3.5**).

More recently, OEH undertook reconnaissance soil landscape assessment mapped at 1:100,000 scale (OEH, 2018). This larger scale survey mapped nine soil and land resource (SLR) units with a variation for three SLR units in the locality (**Figure 3.6**). A brief summary of these is presented below (all information below taken from OEH, 2018).

Sandy Hollow

This SLR unit occurs on gently undulating plains to undulating rises of drainage plains and footslopes. Slopes do not exceed 10% and local relief is low. The underlying geology is Triassic and Permian sedimentary rocks and derived colluvium. Soils in SLR unit are moderately deep to deep, rapidly drained Tenosols and Rudosols, moderately deep to deep, well-drained Red Kandosols and very deep, imperfectly drained Red, Yellow and Brown Sodosols. This SLR unit is mainly used for grazing on improved pasture and some cropping. Limitations are hard-setting A2 horizons and sodic, often dispersible, subsoils. This soil landscape is prone to sheet erosion if the surface is disturbed and gully erosion is likely if water flow becomes concentrated and the dispersible sodic subsoils are exposed. Localised salinity may also be present. Limitations to grazing are rated slight to moderate, limitations to cultivation are rated moderate to high. This SLR unit takes up approximately 39% or 3,035 ha of the locality.

Donalds Gully

Donalds Gully is associated with gently undulating plains to undulating rises comprising footslopes, drainage plains and alluvial fans on Permian Wittingham Coal Measures. Slopes are gentle (1-5%) and local relief is low. Soils in the SLR unit are moderately deep to deep, imperfectly to poorly drained Brown, Yellow and Grey Sodosols and Natric Kurosols, moderately deep to very deep, imperfectly drained Chromosols. Soil with higher fertility may occur on some slopes due to the influence of calcareous or carbonaceous sediments or basalt. These soil types range between moderately deep to deep, moderately well-drained to imperfectly drained Red Dermosols and Chromosols, Hypocalcic Calcarosols, Red and Brown Vertosols and Black Dermosols. The SLR unit is mostly used for grazing of beef, sheep and horses on native pasture. Land degradation includes extensive, minor sheet erosion, rare occurrences of moderate sheet and gully erosion and localised saline outbreaks. Limitations to grazing are rated moderate to high and limitations to cultivation are rated high to very high. This SLR unit takes up approximately 9% or 692 ha of the locality.

Dunwell

This SLR unit is present on undulating rises to rolling low hills on the Triassic Narrabeen Group sandstones and conglomerates. Slopes range from 3% to 15% and the local relief lies between 5 – 20 m. Soils in the Dunwell SLR unit are very shallow to shallow, well to rapidly drained Leptic Tenosols, moderately deep, moderately well to imperfectly drained Red and Brown Kurosols and deep, imperfectly drained Brown Kandosols. This SLR unit is predominantly used for grazing of beef cattle on native and improved pastures. Land degradation includes widespread, moderate to severe sheet and rill erosion is moderate to severe.

Minor gullies occur along drainage lines. Limitations to grazing are rated moderate, limitations to cultivation are rated high to extreme. This SLR unit takes up approximately 3.6% or 278 ha of the locality.

Tingaroo and Tingaroo variant A

The Tingaroo SLR unit occurs on rolling low hills often as foothills on Triassic conglomerates and sandstones. The variant SLR unit Tingaroo variant A is associated with rolling low hills of summit surfaces on conglomerates and sandstones of the Triassic Narrabeen Group. Slopes of the Tingaroo SLR unit are steep (10-30%) and local relief ranges from 30-90 m. Soils of this SLR unit are very shallow, well-drained Clastic Rudosols, shallow to moderately deep, moderately well-drained Brown Kandosols and occasional Red Chromosols, very shallow, imperfectly to moderately well-drained Bleached-Leptic Tenosols and moderately deep, moderately well-drained Black Kandosols. Soils of the Tingaroo variant A are discontinuous, shallow, well-drained Orthic and Leptic Tenosols.

The land use of the Tingaroo variant A is primarily unused woodland and includes the Manobalai Nature Reserve. The Tingaroo SLR unit is mostly used for grazing of beef cattle on native pastures and some areas are protected from stock and support regenerating native vegetation. Land degradation for Tingaroo include extensive minor to moderate sheet erosion and minor gully erosion along some drainage lines. Land degradation of the variant is sheet erosion events following bushfires. For the Tingaroo SLR (Tingaroo variant A) limitations to grazing are rated moderate (moderate) and limitations to cultivation are rated high to very high (extreme). This SLR unit (and its variation) takes up approximately 7.8% (variant A 0.5%) or 608 ha (variant A approximately 40 ha) of the locality.

Wingen Maid

This SLR unit is associated with rugged rolling hills to very steep hills on Triassic Narrabeen Group sediments. Slopes are steep (25-80%) and local relief exceeds 120 m. The soils of the Wingen Maid SLR unit consist of very shallow to shallow, well to moderately well-drained Clastic Rudosols and Orthic Tenosols, moderately deep, moderately well-drained Grey Tenosols and Dermosols and shallow, poorly drained Clastic Rudosols. Land uses of this SLR largely consist of nature conservation or as unused freehold land. Sheet erosion is common following bushfires, minor rill erosion and mass movement as rock fall can occur. Limitations to grazing are rated high to extreme and limitations to cultivation are rated extreme. This SLR unit takes up 6.7% or 523.1 ha of the locality.

Widden

The Widden SLR unit is present on level to gently undulating plains of tributaries of the Goulburn River. In the case of the locality this is the plains of Wybong Creek. Slopes are less than 3% and local relief very low (<10 m). Soils of this SLR unit are moderately deep to deep, well-drained Stratic Rudosols, very deep, moderately well-drained Brown Chromosols, very deep, moderately well-drained Brown Kandosols, deep, moderately well-drained Brown and Black Dermosols, moderately deep to very deep, poorly drained Oxyaquic Hydrosols and very deep, imperfectly drained Brown Sodosols. The Widden SLR is predominantly used for dairy, beef and horse grazing on improved pastures, with some cropping occurring as well. Land degradation is limited to minor streambank erosion along drainage lines. Limitations to grazing are rated as slight and limitations to cultivation are rated slight as well. This SLR unit takes up approximately 7.9% or 614 ha of the locality.

Benjang and Benjang variant A

The Benjang SLR unit is associated with undulating rises with occasional flat sandstone crests on undifferentiated Permian Singleton Coal Measures. Slopes range from 0-10% and the local relief is less than 30 m. The Benjang variant A SLR unit occurs on rolling low hills to steep low hills comprising flat-topped

rolling valley foothills on Permian undifferentiated sediments and Wollombi Group sediments. Slopes are steeper, ranging from 10-40% and local relief lies between 30 m and 90 m.

Soils of the Benjang SLR unit are shallow, well-drained Rudosols and Tenosols, moderately deep, moderately well-drained Haplic Red and Brown Chromosols grade into mottled Natric Red and Brown and Chromosols on midslopes. Deep, imperfectly to poorly drained Red and Brown Sodosols are common on lower slopes and drainage plains. The soils of the SLR unit variant are shallow, stony well-drained Leptic Rudosols shallow to moderately deep, well-drained Red Chromosols, moderately deep, well-drained Brown Chromosols and deep, imperfectly drained Red Chromosols and Sodosols.

Both SLR units are extensively cleared and used for grazing on voluntary, native pastures. Land degradation of the Benjang SLR unit and its variant can occur due to the highly erodible subsoils and regolith. For the Benjang SLR (Benjang variant A) limitations to grazing are rated slight to moderate (moderate) and limitations to cultivation are rated moderate (extreme). This SLR unit (and its variation) takes up 9.5% (variant A 2.2%) or approximately 738 ha (variant A approximately 168 ha) of the locality.

Ant Hill

The Ant Hill SLR unit occurs on rolling hills with benched side slopes on Tertiary Basalt. Slopes range from 20-32%, local relief varied between 90-200 m. Soils of this SLR unit are moderately deep to very deep, moderately well to well-drained Haplic Eutrophic Black, Red and Brown Dermosols and Chromosols , shallow to very deep, moderately well to well-drained Black and Red Vertosols and Red Dermosols and very shallow to shallow, well-drained Clastic Rudosols and Tenosols. Land use of the Ant Hill SLR unit is largely grazing on native and improved pastures. Moderate sheet and rill erosion is common. Moderate gully erosion is common in areas with a history of over-stocking. Terracetting occurs in over-cleared areas in conjunction with grazing practices on steeper slopes. Severe erosion can also be found in places. Limitations to grazing are rated as moderate to high and limitations to cultivation are rated as very high to extreme. This SLR unit takes up 5.8% or approximately 451 ha of the locality.

Disturbed Terrain and Disturbed Terrain variant A

In the locality Disturbed Terrain relates to areas disturbed by coal mining, with Disturbed Terrain variant A consisting of areas of reshaped and revegetated land associated with mine spoil. Slopes and local relief vary depending on operation and stage of mine. For the Disturbed Terrain variant A the limitations to grazing are rated as moderate to high and limitations to cultivation are rated as very high to extreme. This SLR unit (and its variation) takes up 7.5% (variant A 0.6%) or approximately 587 ha (variant A 46.96 ha) of the locality.

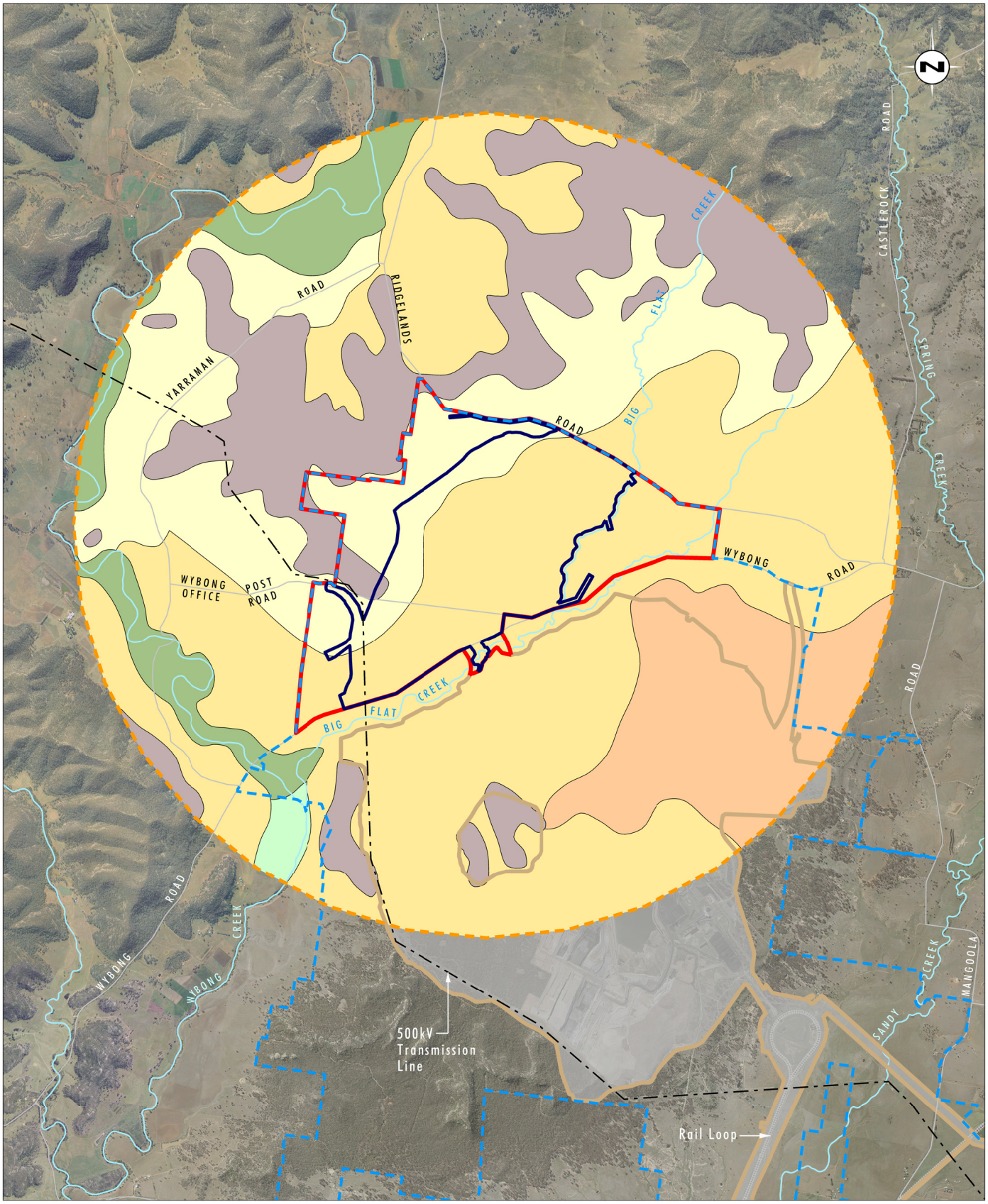


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), OEH - Kovac and Lawrie (2018)

0 1.0 2.0 3.0 km
1:65 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Project Locality

Soil Landscape Mapping Singleton:

- Castle Rock
- Lees Pinch
- Merriwa
- Sandy Hollow
- Wappinguy
- Wollombi

FIGURE 3.4

Soil Landscapes in the Project Locality

File Name (A4): R11/4004_184.dgn
20181116 12.30

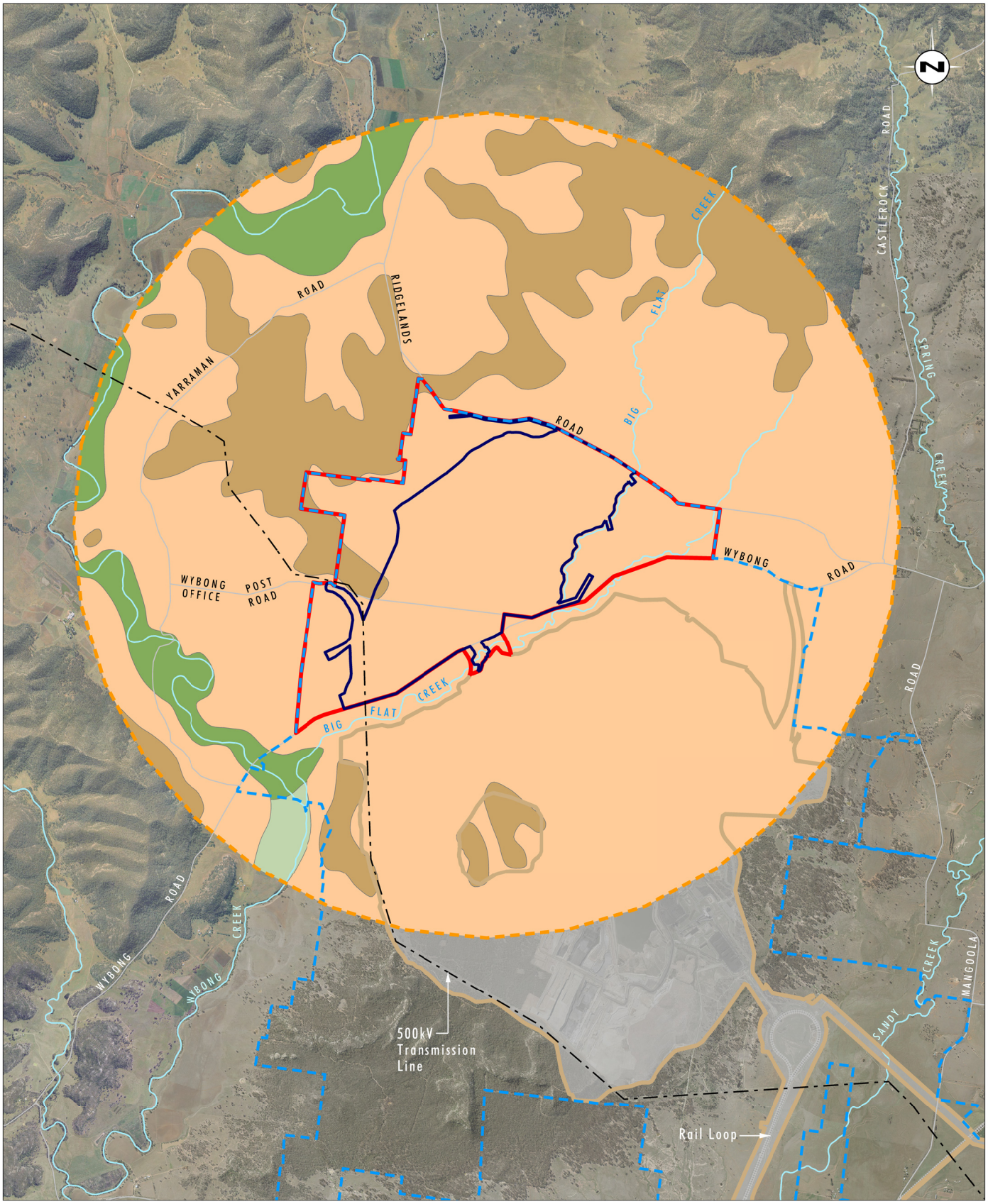


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), OEH (2017)

0 1.0 2.0 3.0km
1:65 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Project Locality

Land and Soil Capability Classes:

- 2 Slight But Significant Limitations
- 3 Moderate Limitations
- 5 Severe Limitations
- 7 Extremely Severe Limitations

FIGURE 3.5

Land and Soil Capability Classes in the Project Locality

File Name (A4): R11/4004_191.dgn
20190515 12.39

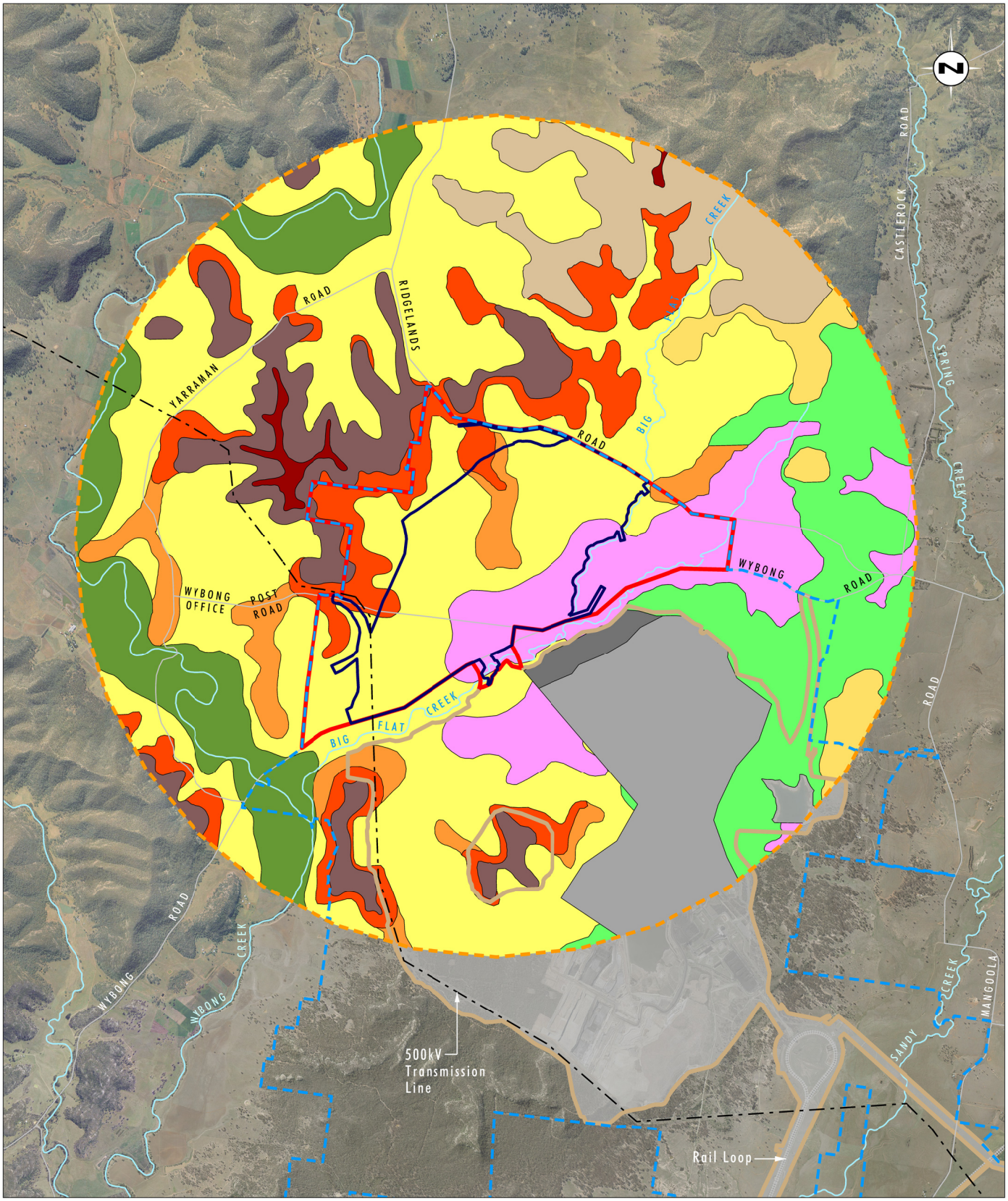


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), Office of Environment and Heritage (OEH 2015)

0 1.0 2.0 3.0km
1:65 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Project Locality

Soil and Land Resources:

- Widden
- Wingen Maid
- Disturbed Terrain
- Disturbed Terrain variant a
- Ant Hill
- Benjang
- Benjang variant a
- Dunwell
- Tinagroo
- Tinagroo variant a
- Donalds Gully
- Sandy Hollow

FIGURE 3.6

Soil and Land Resources in the Project Locality

File Name (A4): R11/4004_234.dgn
20190506 15.06

In summary, the majority of SLR units in the locality are unlikely to be suited to cultivation and intense agriculture. The exception is the Widden SLR unit, which covers approximately 614 ha of the locality and the Benjang SLR unit which had moderate limitations to cultivation (approximately 738 ha). Limitations for grazing were less severe, indicating that approximately 5,480 ha of the locality were able to maintain grazing, if careful management practices are in place (limitations to grazing moderate or less) (refer to **Table 3.3**).

Table 3.3 Summary of soil and land resource (SLR) units in the locality and limitations to land use practices (based on OEH, 2018).

SLR unit	Limitation to cultivation	Limitation to grazing	Deducted LSC Class*	Approx. Area (ha)
Widden	Slight	Slight	2	614
Benjang	Moderate	Moderate	3	738
Sandy Hollow	Moderate to high	Slight to moderate	4	3,035
Benjang variant A	Extreme	Moderate	5 to 6	168
Dunwell	High to extreme	Moderate	5 to 6	278
Tingaroo	High to very high	Moderate	5 to 6	607
Tingaroo variant A	Extreme	Moderate	5 to 6	40
Donalds Gully	High to very high	Moderate to high	6	692
Ant Hill	Very high to extreme	Moderate to high	6 to 7	451
Disturbed Terrain variant A	Very high to extreme	Moderate to high	6 to 7	47
Wingen Maid	Extreme	High to extreme	7	523
Disturbed Terrain	NA	NA	8	587

*based on limitations to grazing and cultivation and LSC definition shown in **Table 3.2**

3.4 Water resources

3.4.1 Surface Water

The MCCO Additional Project Area and locality is situated to the east of the perennial Wybong Creek, with some of the locality area intercepting the creek. Wybong Creek is a major tributary of the Goulburn River. The catchment of Wybong Creek covers an area of approximately 67,370 ha at its confluence with Big Flat Creek and its total catchment area at the confluence with the Goulburn River is approximately 80,040 ha. Wybong Creek immediately upstream of its confluence with Big Flat Creek, and between Big Flat Creek and the Goulburn River, ranges in width between 80 and 100 m. Bank heights in this area range from 2.5 m to in excess of 20 m.

Spring Creek and Sandy Creek, a tributary of the Hunter River, are situated to the east of the locality. Several small farms dams are located on the small, ephemeral creeks to enhance water reliability (**Figure 3.7**).

Big Flat Creek is an ephemeral creek that drains in a south-westerly direction parallel to Wybong Road. Big Flat Creek joins Wybong Creek in the south-western extent of the locality approximately 12 km upstream of the confluence of Wybong Creek and the Goulburn River. The headwaters of Big Flat Creek are located approximately 9.8 km north-east of its confluence with Wybong Creek in woodland areas in the vicinity of Black Jack Mountain. An unnamed tributary of Big Flat Creek has its headwaters in the southern side of the rolling hills and runs south through the MCCO Additional Project Area. Big Flat Creek and its tributaries are noticeably degraded in some sections and are of higher quality in areas less disturbed by land clearing and agriculture. At its closest point to the MCCO Additional Project Area, Big Flat Creek generally has a defined bed and bank with some areas having more extensive eroded banks and vegetation consisting predominately of degraded pasture. Within the MCCO Additional Project Area, tributaries generally comprise small swales/depressions with denuded vegetation in the upper reaches and channels in the lower reaches with active erosion.

The locality drains predominantly to the north-west towards Wybong Creek and to the south into Big Flat Creek. The MCCO Additional Project Area is located to the south-east of the rolling hills which run from north-east to south-west of the locality (**Figure 3.7**). The area to the south of Wybong Road is already impacted by the Approved Project Area.

Both Wybong Creek and Big Flat Creek have a slightly alkaline water pH trend. The median pH for the Wybong Creek is 8.2 upstream of Big Flat Creek and 8.0 downstream of it. The median pH of Big Flat Creek is 8.0 at both the upstream and downstream gauging stations (HEC, 2019).

The electrical conductivity (EC) of Big Flat Creek is considered high for a natural system. The upstream gauging station measured a median EC of 10,270 µS/cm and the downstream station recorded median of 5,165 µS/cm. The highest measured EC was 50,500 µS/cm, which was recorded at the upstream station. Measured EC of Wybong Creek lies between 143 and 8,845 µS/cm, with median EC values of 1,626 µS/cm upstream and 2,040 µS/cm downstream of the Big Flat Creek confluence.

Measured total dissolved solids (TDS) values of Big Flat Creek exceeded the ANZECC Guidelines for Primary Industries (Livestock Drinking Water, beef) 58% of the time upstream and 41% of the time for downstream measurements. The exceedances of Wybong Creek of these TDS ANZECC trigger values are 0.1% and 2.8% upstream and downstream of the Big Flat Creek confluence, respectively (HEC, 2019).

Wybong Creek is the main agricultural water resource in the locality. The high TDS values of Big Flat Creek in combination with its strongly ephemeral nature make means that this creek has a very low to no value as an agricultural resource.

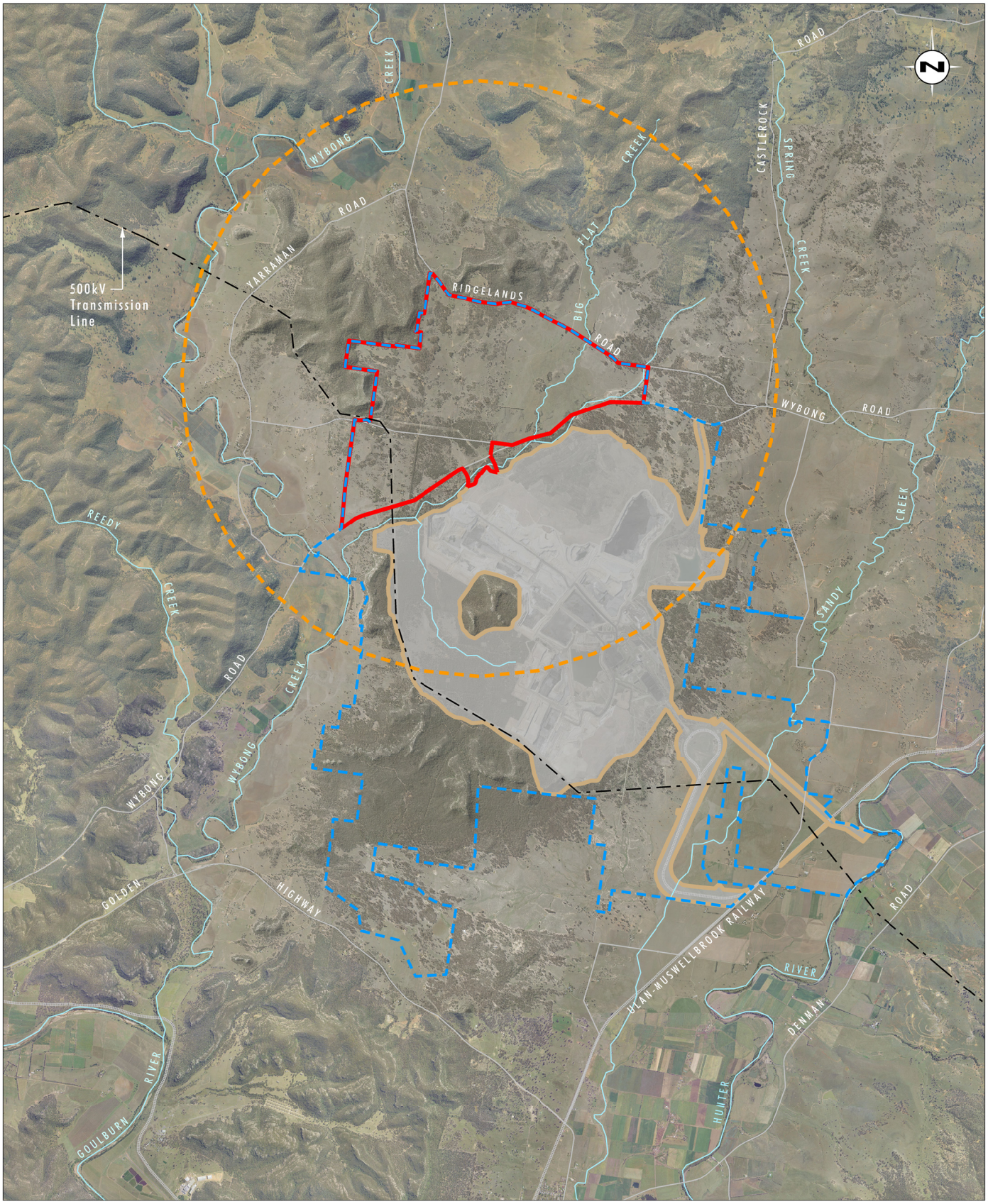


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 1.0 2.0 4.0km
1:90 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality

FIGURE 3.7

Surface Water in the Project Locality

3.4.2 Groundwater

A detailed groundwater assessment for the MCCO Project has been completed by AGE (2019) and is included as an appendix to the EIS main volume. The information in this section has been summarised from AGE's report.

There are two groundwater systems, the Quaternary colluvium and alluvial system and the Permian and Triassic porous rock system.

Mangoola currently holds four water licences to extract groundwater required for the Mangoola Coal Mine. The combined allocations for each aquifer type are up to 700 ML/annum groundwater from the porous rock aquifers including the Permian Newcastle Coal Measures and Triassic Narrabeen Group sandstones and up to 254 ML/annum groundwater from the alluvial aquifer associated with Wybong Creek.

Quaternary colluvium groundwater system

The Quaternary colluvium groundwater occurs as relatively thin and often unsaturated capping forming a patchy ephemeral aquifer aligned along Big Flat Creek and other tributary drainages. The sediments, which range from sand and gravel sized particles to silts and clays, are overlying Triassic and Permian bedrock. Thus water present in the sediment is due substantially to rain as opposed to intercepted regional groundwater. Colluvium sediments along Big Flat Creek are mapped up to 3.5 m thick, however, immediately next to the creek the colluvium is potentially thicker. The colluvium sediment thickness decreases and transitions to regolith overlying highly weathered bedrock with increasing distance from the creek.

Water quality monitoring along Big Flat Creek has shown that surface water becomes highly saline when it receives groundwater as baseflow. As this water needs to pass through the colluvium to enter the stream it is therefore likely that the colluvium will also contain saline water if it is saturated. This suggests that the Quaternary colluvium groundwater is not suitable as reliable water source for agricultural purposes.

Quaternary alluvial groundwater system

The Quaternary alluvial groundwater forms a relatively extensive alluvial aquifer system within the flood plains of Wybong Creek and Sandy Creek. No highly productive alluvial groundwater units are mapped within the MCCO Proposed Additional Mining Area, but they are present within the locality. The closest highly productive alluvium is associated with Wybong Creek and located approximately 1 km to the west of the MCCO Proposed Additional Mining Area.

The alluvial material is thought to be highly permeable and directly connected to Wybong Creek. Wybong Creek is highly incised into the alluvium and groundwater levels are at a similar elevation to the surface water in the creek. This indicates the creek intersects the regional water table and alluvial groundwater potentially contributes to the creek baseflow. Water levels in bores indicate groundwater depths between 12 m below ground level (mbgl) and 14 mbgl, with no apparent impact of the existing mining activities on the water level . The Wybong Creek alluvium has historically been used as a water source. Bore yields in the locality range from relatively low to high and salinity measurements show a generally 'fresh' to 'brackish' salinity range.

Generally, the Quaternary alluvial groundwater system is a suitable water source for agricultural uses.

Permian and Triassic groundwater system

The Permian and Triassic bedrock sediments that can be divided into:

- thin, generally dry and variably permeable weathered rock (regolith)
- highly weathered water bearing rock along Big Flat Creek
- non coal interburden such as conglomerates and sandstones that forms aquitards
- low to moderately permeable coal seams that act as the most transmissive strata within the coal measures sequence.

The groundwater sourced in the Permian and Triassic geologies are present in confined systems and have an upward gradient. The water quality is brackish to saline quality, which is the main constraint to beneficial groundwater use, such as irrigation, or potable consumption. Metals can also be present in concentrations above ANZECC guideline values for aquatic ecosystems, irrigation, stock, and potable consumption thresholds (ANZECC, 2000). Several bores in the Permian and Triassic groundwater system have a suitable beef cattle stock watering quality. Occasionally exceedances for different metals in several bores have been measured but in most cases the metals exceedances are not consistent across multiple sample rounds. It is therefore possible that beef cattle would be productive if watered from the lower salinity bores.

Surface Water and Alluvial Sources

In accordance with the requirements of the *Water Management Act 2000* surface water use in the locality is managed and regulated under the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources. The locality is mainly in the Wybong Management Zone, which is part of the Wybong Water Source, with some of the eastern extent of the locality overlapping with the Muswellbrook Water Source.

The Water Sharing Rules apply to surface waters in this source and alluvial groundwater if it is highly connected to the surface water and is taken through bores and wells. For the Wybong Creek Water Source, water trading into the water source is prohibited but is permitted between management zones up to the maximum allocated entitlement. For the Wybong and Manobalai Management Zones, this is 6,719 unit shares (DPI Water, 2016a), where 1 unit equates to 1.0 megalitre (New South Wales Government, 2016a).

For the Muswellbrook Water Source, trading into the water source is permitted, if the trade will not increase the total licensed entitlement for the water source. Trading within the water source is permitted but subject to assessment. Transfers between tributaries are not permitted (DPI Water, 2016b).

Hard Rock Groundwater Sources

The locality is part of the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016, situated in the Sydney Basin – North Coast Groundwater Resource. This is the Water Sharing Plan that is relevant to the Permian and Triassic porous rock groundwater system. The long-term annual extraction limit for the locality is 90,000 ML per year and at the time of the development of the North Coast Fractured and Porous Rock Groundwater Sources Water Sharing Plan in July 2016, the unassigned water accounted for 3,453 ML/yr. Groundwater trading into the source is prohibited but trades are permitted within the source, subject to assessment (DPI Water, 2016c).

3.5 Significant Vegetation Communities

Vast areas of the Upper Hunter have historically been cleared for agricultural and industrial land uses. In line with this, extensive clearing has also been carried out in the locality and is evident in historical images dating back to the 1960s (**Figure 3.3**).

There have been 29 native vegetation communities mapped within the locality (OEH, 2018), which are summarised in **Table 3.4**, below. Of these 29 native vegetation communities, 10 are listed as Threatened Ecological Communities (TEC) under the *NSW Biodiversity Conservation Act 2016* (BC Act), while 11 communities conform in part or full to TECs listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Areas with a LSC Class 2 and LSC Class 3 have largely been mapped as not having native vegetation communities or as derived native grasslands. Derived grasslands are also the main vegetation community on LSC Class 5 land, which is used for cattle grazing. Further, narrow-leaved ironbark communities are present on areas of LSC Class 5 land and would provide shelter for grazing animals.

Native vegetation communities on LSC Class 7 land do not provide benefits for existing grazing operations, as the land is unsuitable for agriculture.

Table 3.4 Native vegetation communities in the locality

Vegetation community	Conservation status in NSW	Commonwealth status
Blakelys Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter	Endangered Ecological Community	Critically Endangered
Broom Bush - *Allocasuarina gymnanthera* heathy woodland on sandstone outcrops of the Sydney Basin	Not listed	Not listed
Brown Bloodwood - Currawang - Caleys Ironbark shrubby woodland on sandstone ranges of the Sydney Basin	Not listed	Not listed
Bull Oak grassy woodland of the central Hunter Valley	Not listed	Not listed
Central Tableland Sedge Swamp	Not listed	Not listed
Derived grassland of the NSW South Western Slopes	Not listed	Not listed
Dywers Red Gum - *Micromyrtus sessilis* heathy open woodland on sandstone plateau of the upper Hunter and Sydney Basin	Not listed	Not listed
Forest Red Gum grassy open forest on floodplains of the lower Hunter	Endangered Ecological Community	Critically Endangered Ecological Community
Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South Bioregion (including Pilliga) and Nandewar Bioregion	Endangered Ecological Community	Not listed
Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin	Vulnerable Ecological Community	Critically Endangered Ecological Community

Vegetation community	Conservation status in NSW	Commonwealth status
Grey Box grassy open forest of the Central and lower Hunter Valley	Not listed	Critically Endangered Ecological Community
Grey Gum - Rough-barked Apple shrubby open forest of the lower Hunter	Not listed	Not listed
Hunter Escarpment Slaty Gum-Box Forest	Not listed	Not listed
Narrow-leaved Ironbark - Black Cypress Pine shrub - grass woodland upper Hunter and northern Wollemi	Not listed	Not listed
Narrow-leaved Ironbark - Black Pine - Sifton Bush heathy open forest on sandstone ranges of the upper Hunter and Sydney Basin	Not listed	Not listed
Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter	Endangered Ecological Community	Critically Endangered Ecological Community
Narrow-leaved Ironbark - Grey Box - Spotted Gum shrub - grass woodland of the central and lower Hunter	Endangered Ecological Community	Critically Endangered Ecological Community
Narrow-leaved Ironbark - Grey Box grassy woodland of the central and upper Hunter	Endangered Ecological Community	Critically Endangered Ecological Community
Narrow-leaved Ironbark - Grey Gum - Native Olive woodland of Central Hunter	Not listed	Critically Endangered Ecological Community
Narrow-leaved Ironbark - Grey Gum shrubby open forest on sandstone ranges of the upper Hunter Valley	Not listed	Not listed
Red Ironbark - Grey Gum - Narrow-leaved Stringybark - Brown Bloodwood shrubby open forest on sandstone ranges of the Sydney Basin	Not listed	Not listed
River Oak riparian grassy tall woodland of the western Hunter Valley (Brigalow Belt South Bioregion and Sydney Basin Bioregion)	Not listed	Not listed
Rock outcrops shrublands complex of the lower North Coast	Not listed	Not listed
Spotted Gum - Narrow-leaved Ironbark shrub - grass open forest of the central and lower Hunter	Endangered Ecological Community	Critically Endangered Ecological Community
Spotted Gum - Narrow-leaved Ironbark-Red Ironbark shrub - grass open forest of the central and lower Hunter	Endangered Ecological Community	Critically Endangered Ecological Community
Spotted Gum - Red Ironbark - Grey Gum shrub - grass open forest of the lower Hunter	Not listed	Not listed
Weeping Myall - Plains Grass grassy woodlands of the Brigalow Belt South	Critically Endangered Ecological Community	Critically Endangered Ecological Community

Vegetation community	Conservation status in NSW	Commonwealth status
Western Hunter Flats Rough-barked Apple Forest	Not listed	Not listed
Western Hunter Grey Gum-Stringybark Forest	Not listed	Not listed

4.0 Agricultural Resources within the MCCO Additional Project Area

4.1 Vegetation

The following sections provide a brief overview of the vegetation communities in the MCCO Additional Project Area and proposed offset areas. All information is based on the Mangoola Coal Continued Operations Project - Biodiversity Assessment Report which is an appendix to the MCCO EIS. Generally, vegetation communities provide different services to agriculture and cattle grazing. Woodlands are more beneficial as a shelter for grazing animals, whereas the grasslands and more open woodland areas provide a higher degree of feed but less shelter.

4.1.1 Proposed Disturbance Footprint

In total, there are six vegetation communities in the proposed disturbance footprint of the MCCO Project. The condition of the communities ranged from 'Moderate to Good' to 'Poor' (**Figure 4.1**). The six vegetation communities are

- Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter
- Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open forest of the Central and Lower Hunter
- Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter
- Blakelys Red Gum - Narrow-leaved Ironbark - Rough-barked Apple Shrubby Woodland of the upper Hunter
- Bull Oak Grassy Woodland of the Central Hunter Valley
- Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley.

All areas not mapped as a native vegetation community are defined as 'cleared land'. This mapping unit includes cleared land, non-native vegetation, water bodies and built structures.

The MCCO Project requires the clearance of approximately 570 ha of native vegetation, which consists of 196 ha of woodland and the balance, derived native grassland. The vegetation required to be cleared includes four NSW listed threatened ecological communities, one of which is also listed as Critically Endangered Ecological Community under the EPBC Act.

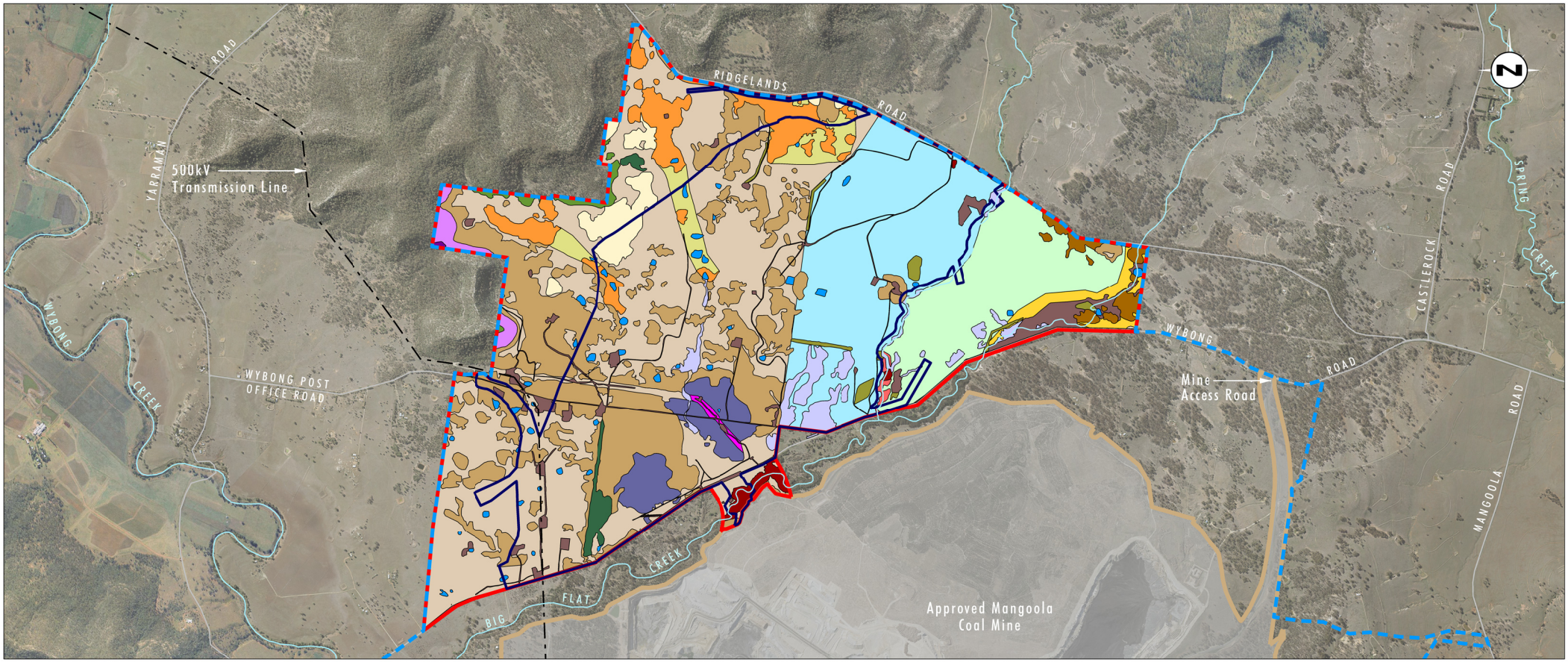


Image Source: Glencore (April 2018)
Data Source: Glencore (2019)

0 0.5 1.0 1.5km
1:40 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area
- Disturbed Land
- Exotic Rushland
- Mixed Species Revegetation Plantation
- Water Body
- HU812/PCT1598 Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter - Moderate to Good
- HU812/PCT1598 - Moderate to Good - Derived Native Grassland
- HU816/PCT1602 Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good
- HU817/PCT1603 Narrow-leaved Ironbark - Bull Oak - Grey Box shrub - grass open forest of the central and lower Hunter - Moderate to Good
- HU817/PCT1603 Moderate to Good - Derived Native Grassland
- HU817/PCT1603 Low - Derived Native Grassland
- HU821/PCT1607 Blakely's Red Gum - Narrow-leaved Ironbark - Rough-barked Apple shrubby woodland of the upper Hunter - Moderate to Good
- HU869/PCT1655 Grey Box - Slaty Box shrub - grass woodland on sandstone slopes of the upper Hunter and Sydney Basin - Moderate to Good
- HU869/PCT1655 Low - Derived Native Grassland
- HU869/PCT1655 Moderate to Good - Derived Native Grassland
- HU906/PCT1692 Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good
- HU906/PCT1692 Moderate to Good - Derived Native Grassland
- HU945/PCT1731 Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Moderate to Good
- HU945/PCT1731 Moderate to Good Condition - Other
- HU695 - Large-fruited Grey Gum - Narrow-leaved Stringybark open forest on sheltered sandstone hillslopes - Moderate to Good
- HU702 - Narrow-leaved Ironbark- Black Cypress Pine - stringybark +/- Grey Gum +/- Narrow-leaved Wattle shrubby open forest on sandstone hills - Moderate to Good
- HU826 - Narrow-leaved Ironbark – Grey Gum – Native Olive Woodland of the Central Hunter - Moderate to Good

FIGURE 4.1

Vegetation Communities in the MCCO Additional Project Area

File Name (A4): R11/4004_249.dgn
20190506 15.14

4.1.2 Proposed Offset Areas

Approximately 30% of the proposed Mangoola offset site has previously been cleared. Six vegetation communities, with varying conditions have been mapped for the site. These are:

- Forest Red Gum Grassy Open Forest on Floodplains of the Lower Hunter
- Spotted Gum – Narrow-leaved Ironbark shrub – Grass Open Forest of the Central and Lower Hunter
- Narrow-leaved Ironbark – Bull Oak – Grey Box shrub – Grass Open Forest of the Central and Lower Hunter
- Blakely's Red Gum – Narrow-leaved Ironbark – Rough-barked Apple shrubby woodland of the Upper Hunter
- Grey Box – Slaty Box shrub – Grass Woodland on Sandstone Slopes of the Upper Hunter and Sydney Basin
- Swam Oak –Weeping Grass Grassy Riparian Forest of the Hunter Valley.

Like with the Mangoola offset site and the MCCO Additional Project Area, large parts of the proposed Wybong Heights offset site have already been cleared for agricultural activities. Native vegetation communities mapped are:

- River Red Gum – River Oak riparian woodland wetland in the Hunter Valley
- Narrow-leaved Ironbark – Grey Box grassy woodland of the upper Hunter Valley, mainly Sydney Bain Bioregion
- River Oak Riparian Grassy tall woodland of the Western Hunter Valley
- Rough-barked Apple – Red Gum – Yellow Box woodland on alluvial clay to loam soils
- White Box x Grey Box – Red Gum – Rough-barked Apple grassy woodland on rich soils in the Upper Hunter Valley
- Spotted Gum – narrow-leaved Ironbark shrub – grass open forest of the Central and Lower Hunter
- Blakey's Red Gum – Narrow-leaved Ironbark- Rough-barked Apple shrubby woodland of the Upper Hunter
- Narrow-leaved Ironbark – Grey Gum shrubby open forestry on sandstone ranges of the Upper Hunter Valley.

4.2 Water resources

Water resources in the MCCO Additional Project Area have been discussed in detail in **Section 3.4**. The ephemeral Big Flat Creek is the main drainage line in the area and has limited to no value as an agricultural resource. Several smaller, unnamed drainage lines are present as well. Several small stock water dams are present in the MCCO Additional Project Area, serving as a more secure stock water source throughout the year.

The MCCO Additional Project Area is situated in the Upper Hunter Valley, which has been assessed to a reliable water supply by the Interim Protocol. This is based on annual precipitation of 350 mm or more in nine out of 10 years (OEH and OASFS, 2013). OEH (2014) climate change projections for the Upper Hunter suggest lower reliability of access to surface water in summer, with higher temperatures, lower seasonal rainfall and higher evaporation rates.

4.3 Topography

The majority (663.7 ha, 62.5%) of the MCCO Additional Project Area has a gentle slope between 0-5% (**Figure 4.2**). Generally speaking, these gentler slopes have a higher potential for agricultural use due to a reduced erosion hazard. However, the erosivity of an area is also determined by slope length and underlying soil type. Slope length of these gentle slopes running to Big Flat Creek can range up to 3,000 m and thus pose a significant erosion risk.

Approximately 250 ha (23.5%) have a slope between 5-10% and approximately 149 ha (14.0 %) have slopes exceeding 10% (**Figure 4.2**). The latter (>10%) severely limits agriculture due to high erosion risks, especially for cleared areas. Slopes between 5-10% may be used for agriculture but management strategies must be in place to minimise erosion risk and mitigate erosion damage to the land. As with slopes of 0-5%, slope length and soil type are key drivers of the agricultural suitability of these steeper slopes.

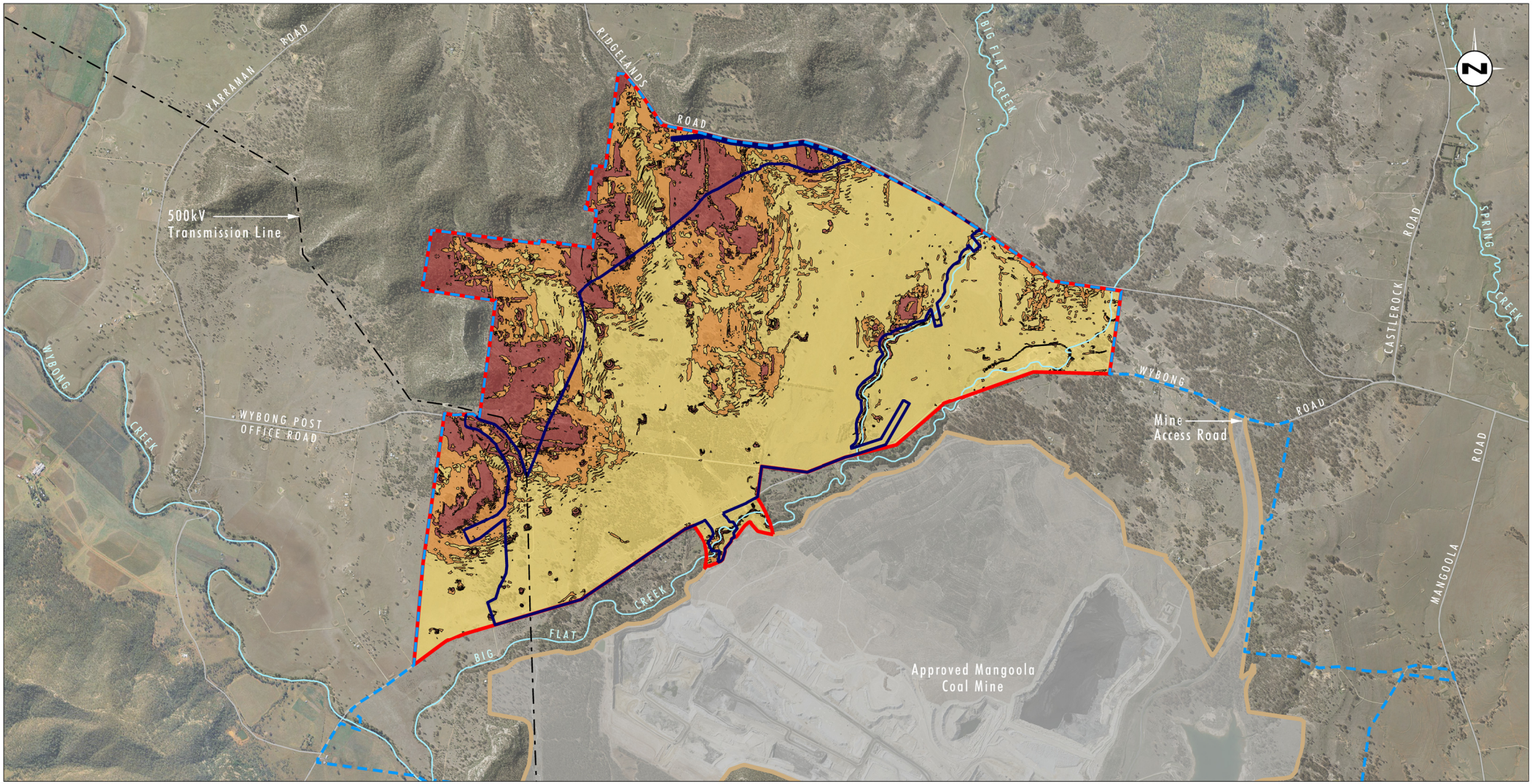


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), EMM (2019)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area

Slope:
- 0-5%
- 5-10%
- Greater than 10%

FIGURE 4.2

Slope Analysis in the MCCO Additional Project Area

File Name (A4): R11/4004_244.dgn
20190514 9.32

4.4 Soil

4.4.1 MCCO Additional Project Area

A comprehensive soils assessment has been undertaken for the MCCO Project by EMM (2019) with a summary of the key findings as relevant to the AIS provided in this section and the full report provided as an Appendix to the MCCO Project EIS.

The soils assessment has focused on the proposed mining operations within the MCCO Additional Project Area and has been completed to assess the soil types to map any BSAL that may occur.

4.4.1.1 Soil Landscapes and Soil and Land Resources

There are three soil landscapes in the MCCO Additional Project Area. These are the Lees Pinch landscape, associated with the steep hills in the north-western extent of the MCCO Additional Project Area, the Wappinguy landscape, approximately linked to the midslope of the rolling hills, and the Sandy Hollow landscape, which is related to the lower slope of the rolling hills and the Big Flat Creek floodplain and plain (**Figure 3.4**). A description of these landscapes is provided in **Section 3.3** and **Table 3.1**.

Five SLR units (OEH 2018) were mapped in the MCCO Additional Project Area. These are Sandy Hollow (599 ha, 56.4%), Donalds Gully (265 ha, 25.0%), Tingaroo (138 ha, 12.9%), Dunwell (53 ha, 5.0%) and Wingen Maid (7.6 ha, 0.7%) (**Figure 3.6**). Limitations to cultivation for Sandy Hollow are rated as moderate to high. All other SLR units in the MCCO Additional Project Area have limitations to cultivation rated as high or more severe. As a result, cropping is unlikely to be a suitable land use for the area. Sandy Hollow, Dunwell and Tingaroo are likely well suited to grazing with appropriate management strategies in place. Grazing may be limited on Donalds Gully and unsuitable for Wingen Maid (**Table 3.3**). A discussion of the SLR units is provided in **Section 3.3**.

4.4.1.2 Soil Types

The soil survey completed by EMM (2019) identified five soil types in the MCCO Additional Project Area, namely Sodosol, Tenosol, Kurosol, Dermosol and Chromosol. Chromosols were only encountered in two survey sites and, due to this limited distribution, not mapped within the MCCO Additional Project Area. Rudosols are likely to be present on the hillcrests and upper hill slopes in the western margin of the MCCO Additional Project Area. These areas will not be disturbed by the proposed mining activities and thus the survey effort in that area was reduced. As a result the occurrence of Rudosols was not validated by soil survey sites (**Figure 4.3**).

Sodosols are the dominant ASC Order in the MCCO Additional Project Area, occurring on all slopes and crests of low rolling hills throughout the MCCO Additional Project Area (**Figure 4.3**). This soil type shows a strong texture contrast between the A and B Horizons. The Exchangeable Sodium Percentage (ESP) of the upper B Horizon is greater than six, which can lead to a high erodibility, poor structure and low permeability of the subsoil. The surface is generally hard setting. Land mapped as Sodosol has been extensively cleared for grazing. Sites analysed in the laboratory (5 profiles) were identified as Mesotrophic Mesonatric Grey Sodosol. Sodosols were mapped on 67% (approximately 707 ha) of the MCCO Additional Project Area.

Tenosols were found in the north western extent of the MCCO Additional Project Area and as a band running from north to south in the eastern part of the MCCO Additional Project Area (**Figure 4.3**). This soil type typically had sandy loam textures in the A horizon and loamy sand textures throughout the B profile. The soil surface is firm when dry without coarse fragments. Coarse fragments are distributed in the soil column and can reach 50-90%. The Tenosol soil unit occurs on slopes and crests of undulating hills on

sandstone and conglomerate surface geology. Areas of mapped Tenosol have been extensively cleared for grazing, with some scattered pockets of woody vegetation also being present. Tenosols analysed in the laboratory (3 profiles) were identified Basic Arenic Red-Orthic Tenosol. Tenosols covered 24% (approximately 260 ha) of the MCCO Additional Project Area.

Dermosols were mapped in the south-western part of the MCCO Additional Project Area. They occur on gently inclined rolling low hills associated with the localised back plain or meander of Big Flat Creek (**Figure 4.3**). This soil type has an A Horizon of moderately high fertility and poorly drained, sodic and saline B Horizons. Subsoils commonly have red and orange mottling with no segregations. Few coarse fragments are distributed in the lower A and upper B Horizon. The soil surface is mostly without coarse fragments and of firm condition. Within the MCCO Additional Project Area, land use on this soil type is for grazing with riparian zones remaining vegetated. Dermosols analysed in the laboratory (3 profiles) were identified as Sodic Eutrophic Brown Dermosols. Dermosols were present on 6% (approximately 66 ha) of the MCCO Additional Project Area.

Kurosols in the MCCO Additional Project Area occurred on some gentle to moderate slopes of the quaternary depositional geology (**Figure 4.3**). Kurosols are texture contrast soils with acid (pH<5.5) B Horizons. The soil surface is generally hard setting. Fine gravel is dispersed through the A Horizons and the B Horizon is acidic decreasing to mildly acidic with depths. The two soil profiles analysed in the laboratory were identified as Magnesic-Natric Grey Kurosols. Kurosols occurred on 3% (approximately 29 ha) of the MCCO Additional Project Area.

Chromosols in the MCCO Additional Project Area have a strong texture contrast between the A and B Horizons. This soil was encountered on gently undulating hills, which were cleared for grazing. Chromosols had a soil surface without surface fragments but with fine gravel in the lower A and throughout the B Horizons. Chromosols analysed in the laboratory (2 profiles) were identified as Mottled Mesotrophic Brown Chromosols. Chromosols were only encountered in two survey sites in singular locations. Due to the limited occurrence this Soil order was not mapped.

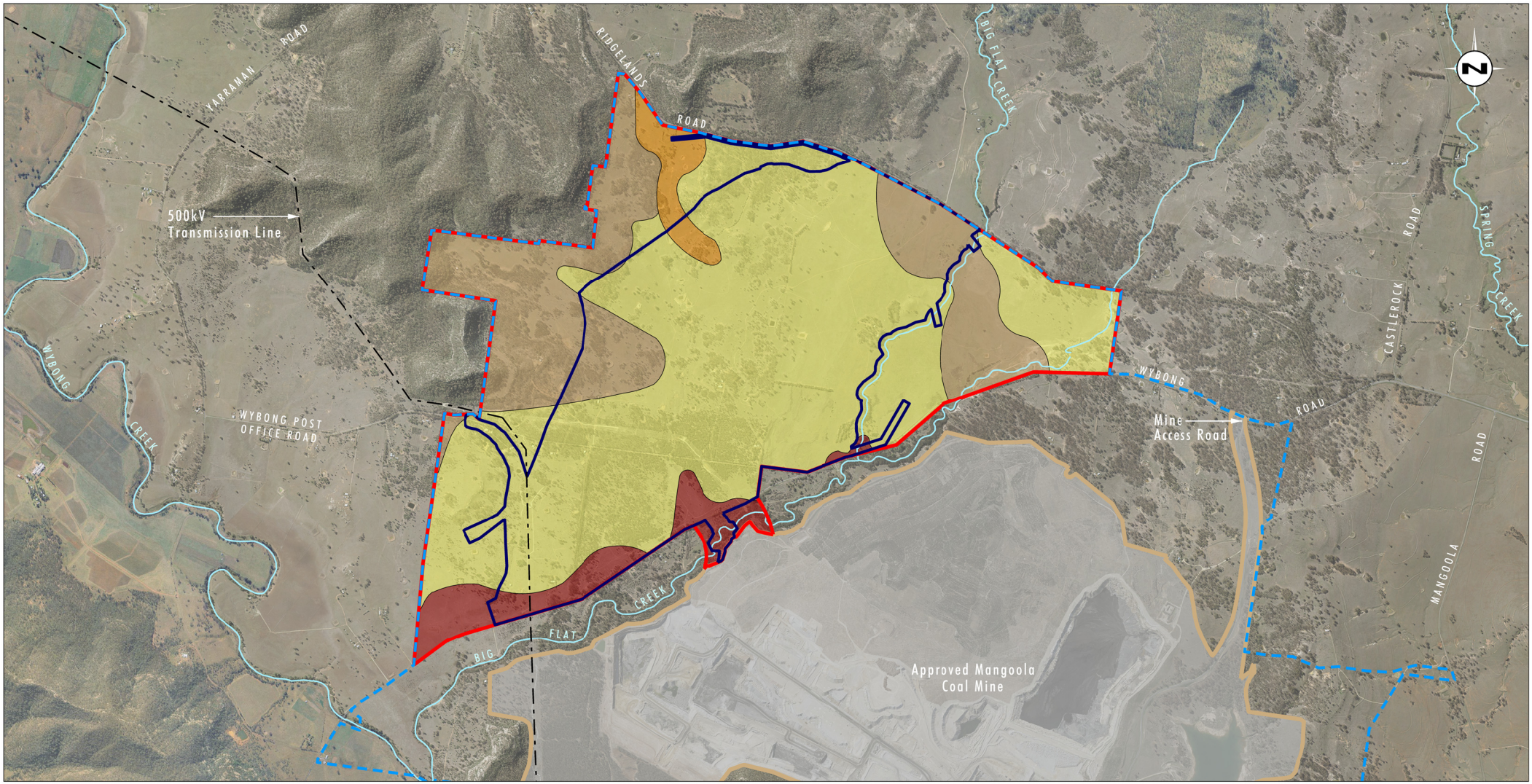


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), EMM (2019)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area

Soil Types:
- Dermosol
- Kurosol
- Sodosol
- Tenosol

FIGURE 4.3

Soil Types in the MCCO Additional Project Area

File Name (A4): R13/4004_245.dgn
20190514 9.33

4.4.1.3 Soil Fertility

The analysed Sodosols showed mostly low levels of macronutrients, low to moderate levels of micronutrients and a very low cation exchange capacity (CEC). The fertility ranking of this soil type was moderately low. As a result, the fertility of this soil type only supports plants suited for grazing. In addition to the moderately low fertility, high sodicity below 0.1 m is a major constraint to agriculture.

Laboratory analysis of the Tenosols in the MCCO Additional Project Area showed that this soil type had low levels of macronutrients, low to moderate levels of micronutrients and very low CEC. The fertility was ranked as moderately low, limiting agricultural activities to grazing. Further, the low water holding capacity of this soil type presents an additional limitation for cropping.

Dermosols showed deficiency in some macronutrients (e.g. nitrate and nitrite, P, total K), low to moderate levels of micronutrients and a very low CEC. The fertility ranking of this soil type was moderately low. Further, the soil profile becomes highly sodic below 0.1 m. These factors severely limit the agricultural usage of areas with Sodic Eutrophic Brown Dermosols.

Analysed Kurosols showed mostly very low levels of macronutrients, low to moderate levels of micronutrients and a very low CEC. The fertility was ranked as moderately low, restricting agricultural land use to grazing. Further surface acidity would restrict some agriculture.

Macronutrient levels of the analysed Chromosol samples were mostly very low and micronutrient levels were low to moderate. The CEC was very low. Based on this, the fertility was ranked as moderately low, which restricts sustainable agriculture to grazing. Subsoil mottling indicates water logging, which further could restrict agricultural use of this soil type within the MCCO Additional Project Area.

4.4.1.4 Land and Soil Capability

LSC mapping carried out by OEH (OEH, 2012a) showed that the steep slopes in the north west of the MCCO Additional Project Area are LSC Class 7 (35 ha, 3.3%), while the remainder of the area was assessed as LSC Class 5 (1,027 ha, 96.7%) (**Figure 3.5**).

As part of the soil assessment for the MCCO Project, the existing LSC mapping has been revised by EMM (2019). The re-classification was based on relevant OEH guidelines, field observations, laboratory analysis and spatial analysis (slope analysis).

The review and reclassification of LSC Class 5 land confirmed 53% (approximately 560 ha) of the MCCO Additional Project Area as being LSC Class 5. Soil Orders of this LSC Class are predominantly Sodosol, with Dermosol and Kurosol also being present (**Figure 4.4**).

Parts of previously mapped LSC Class 5 land has now been assessed as being LSC Class 7 (approximately 135 ha), while other areas previously classed as LSC Class 5 have been remapped as LSC Class 4 and LSC Class 3.

After reclassification, LSC Class 4 made up 29% (approximately 313 ha) of the MCCO Additional Project Area and was mapped in the east and south as well as in the central-west. Soil types related to the LSC Class 4 were Dermosols, Sodosols and Tenosols. LSC Class 3 areas (approximately 54 ha) where identified in three smaller parcels throughout the MCCO Additional Project Area. Soil types of LSC Class 3 were Sodosol, Tenosol and Dermosol (**Figure 4.4**).

Based on the reclassified LSC and **Table 3.3**, the majority of the MCCO Additional Project Area may be suited for grazing (LSC Class 4 and LSC Class 5), with a small portion where cropping may be a viable

possibility (LSC Class 3). However, the small sizes of the LSC Class 3 land parcels, most likely would restrict viable infrastructure. The LSC Class 7 of the steep terrain in the north-west is not suited for agricultural use.

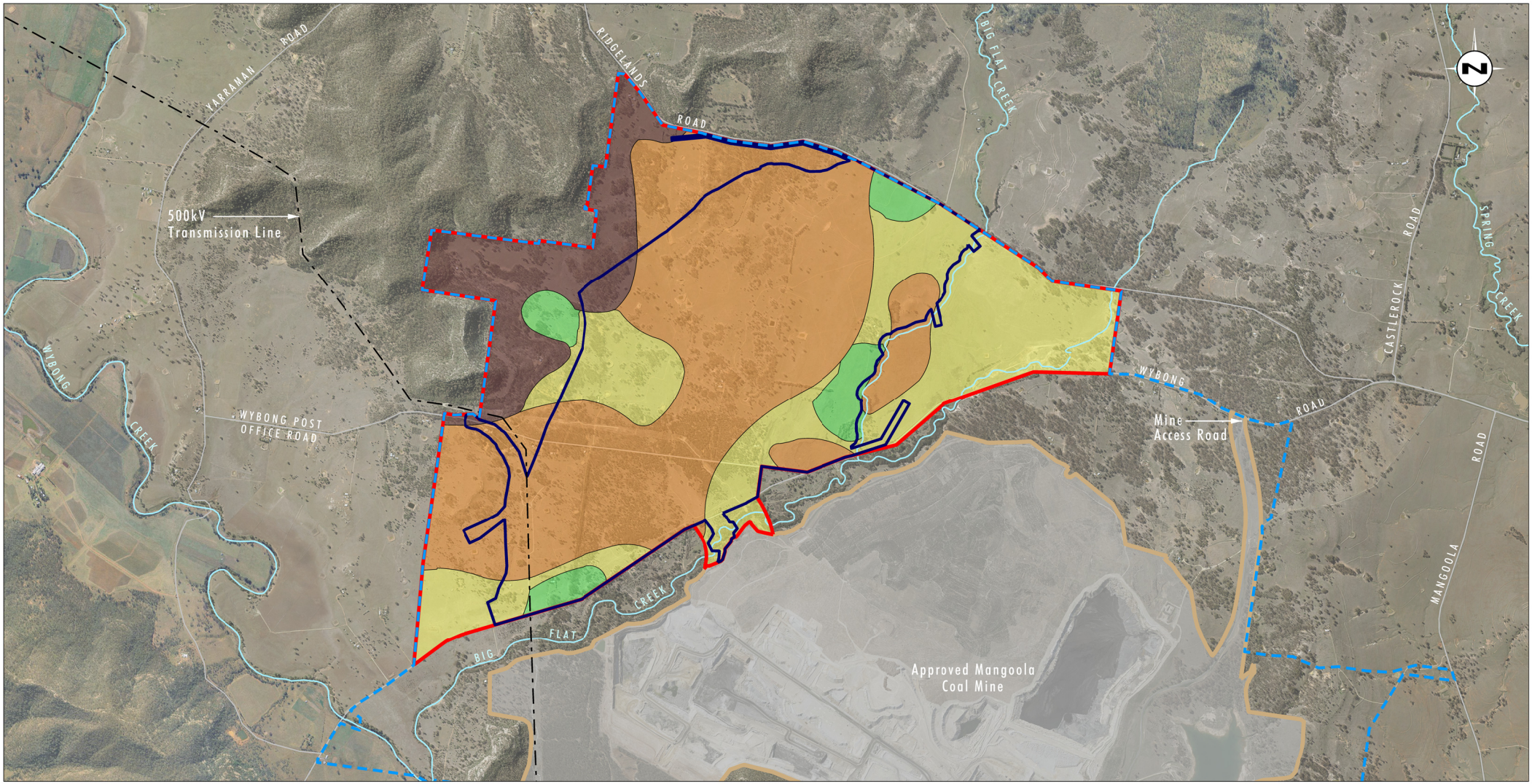


Image Source: Glencore (April 2018)
Data Source: Glencore (2019), EMM (2019)

0 0.5 1.0 2.0km
1:40 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- MCCO Additional Disturbance Area

Re-classified Land and Soil Capability Classes:

- Class 3
- Class 4
- Class 5
- Class 7

FIGURE 4.4

Re-classified Land and Soil Capability Class

File Name (A4): R13/4004_235.dgn
20190514 9.33

4.4.1.5 Biophysical Strategic Agricultural Land

A detailed BSAL assessment of the MCCO Additional Project Area was undertaken following the Interim Protocol and is included in the Soils report which is provided as an Appendix to the MCCO Project EIS. As part of this assessment each soil type identified in the MCCO Additional Project Area was assessed against the BSAL criteria. None of the soil types present were found to satisfy the criteria, with most failing multiple physical and chemical soil criteria. In addition, an analysis of slope in the MCCO Additional Project Area determined that some land failed the slope criterion. The result is that no BSAL is present in the MCCO Additional Project Area, a conclusion that is consistent with the results of the broader scale NSW Government's BSAL mapping contained in the SRLUP.

Subsequently, a Site Verification Certificate was issued by DPE on 10 December 2018 confirming the absence of BSAL.

4.4.2 Proposed Offset Areas

The following section will discuss the soil and landscape values of the proposed Mangoola and Wybong Heights offset sites as shown in **Figure 1.3**. The description of the soil landscapes and soil properties is based on mapping as shown in eSpade[5]. Soil landscape mapping was undertaken by the Soil Conservation Service of NSW and the locality is situated in the 1:250 000 Singleton mapping area (Kovac and Lawrie, 1991). Further, ASC soil mapping (1: 250 000 scale), based on LSC Class mapping, for the whole of NSW was undertaken by OEH (OEH, 2017a, OEH, 2017b).

Soil landscapes in the proposed offset areas are shown in **Table 4.1** and **Figure 4.5**. A description for all but the Rossgole soil landscapes, LSC Classes and ASC mapping is provided in **Table 3.1**.

The Rossgole soil landscape is described as occurring on plateaus of undulating low hills and hills, ranging in elevation from 400 – 640 m. Local relief is 60 – 120 m. Slopes are 2 – 7%, with slope lengths ranging from 500 – 2000 m. Drainage lines occur at 200 m intervals. The underlying geology is tertiary basalt (Kovac and Lawrie, 1991). The maximum elevation of the Rossgole soil landscape at the proposed offset areas is approximately 410 m.

The associated Great Soil Groups for the Rossgole soil landscape are Black Earths on steeper slopes with Euchrozems on the flatter slopes. The erosion hazard is rated as moderate, as is the structural degradation hazard. The mass movement hazard is rated low (Kovac and Lawrie, 1991). The Rossgole soil landscape in the proposed offset areas is mapped as a Vertosol (OEH, 2017a), with a LSC Class 3 (OEH, 2017b).

[5] http://www.environment.nsw.gov.au/eSpade2WebApp, accessed 03/10/2018

Table 4.1 Soil landscapes in the proposed offset areas

Soil landscape	Mangoola (ha)	Wybong Heights (ha)	Total Area (ha)
Lees Pinch[1]	73.7	539.1	612.8
Merriwa	0	7.0	7.0
Rossgole	0	141.0	141.0
Sandy Hollow	471.0	31.8	502.8
Wappinguy[2]	460.2	42.1	502.3

[1] Please note that 28.2 ha of this landscape are located inside the MCCO Additional Project Area
[2] Please note that 166.4 ha of this landscape are located inside the MCCO Additional Project Area

The majority of the proposed offset areas consist of LSC Class 5 and LSC Class 7. Thus extremely severe (LSC Class 7) to severe (LSC Class 5) limitations for high impact agricultural land uses occur for the majority of the proposed offset areas (**Table 4.2**, **Figure 4.6**). The Wybong Heights plateau with the Rossgole soil landscape is mapped as a LSC Class 3, and therefore deemed to be capable of sustaining high impact agricultural land uses if appropriate management practices are applied. Areas associated with the Wybong Creek floodplain (Merriwa soil landscape) have a LSC Class 2 and thus these areas are capable of sustaining high impact agricultural land uses when managed appropriately (**Figure 4.5**, **Figure 4.6**).

Table 4.2 Land and soil capability classes and size in the proposed offset area

LSC Class*	Mangoola (ha)	Wybong Heights (ha)	Total Area (ha)
1	0	0	0
2	0	8.7	8.7
3	0	141.0	141.0
4	0	0	0
5[1]	931.1	68.6	999.8
6	0	7.3	7.3
7[2]	73.7	521.3	595.0
8	0	14.1	14.1

*OEH, 2013, [1] Please note that 166.4 ha of this LSC Class are located inside the MCCO Additional Project Area
[2] Please note that 28.2 ha of this LSC Class are located inside the MCCO Additional Project Area

There are 13 SLR units mapped within the proposed offset areas (**Figure 4.7**). These are presented in **Table 4.3** and shown in **Figure 4.7.**

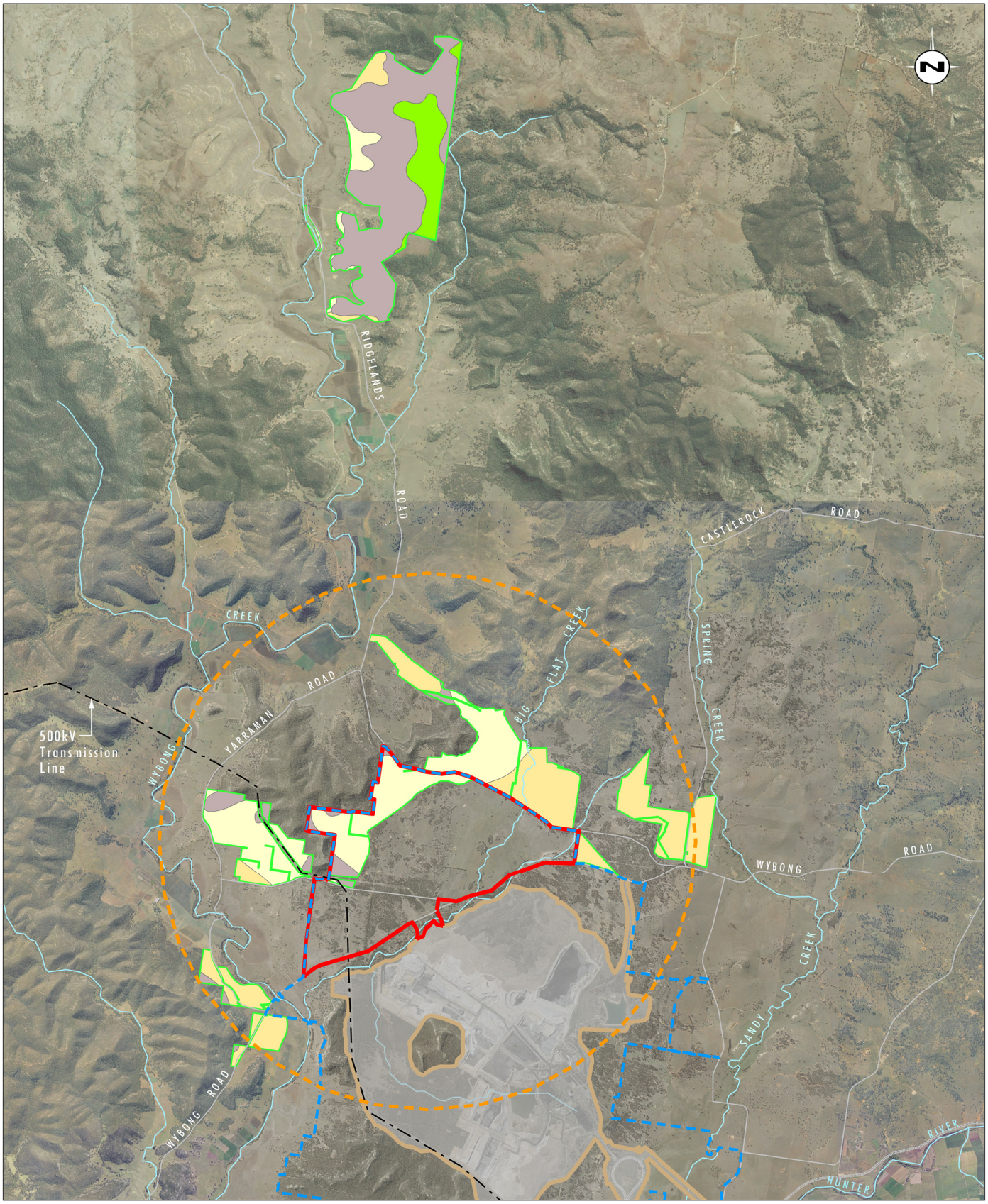


Image Source: Glencore (April 2018), Google Earth (Sept 2018)
Data Source: Glencore (2019), OEH - Kovac and Lawrie (2018)

0 1.0 2.5 5.0km
1:100 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality
- Proposed Offset Site

Soil Landscape Mapping Singleton:

- Lees Pinch
- Merriwa
- Rossgole
- Sandy Hollow
- Wappinguy

FIGURE 4.5

Soil Landscapes in the Proposed Offset Sites

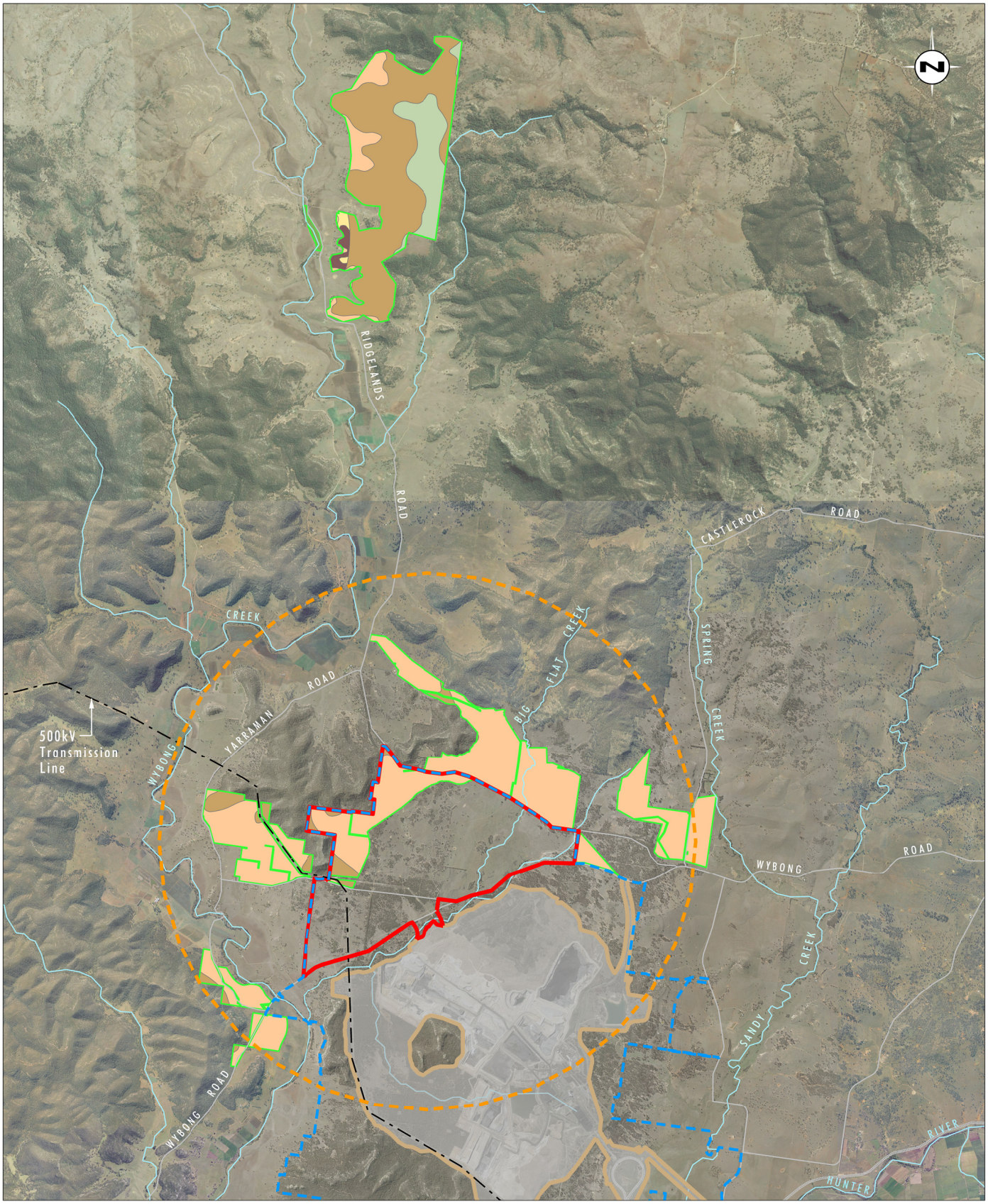


Image Source: Glencore (April 2018), Google Earth (Sept 2018)
Data Source: Glencore (2019), OEH (2017)

0 1.0 2.5 5.0km
1:100 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality
- Proposed Offset Site

Soil Landscape Mapping:

- 2 Slight But Significant Limitations
- 3 Moderate Limitations
- 5 Severe Limitations
- 6 Very Severe Limitations
- 7 Extremely Severe Limitations
- 8 Extreme Limitations

FIGURE 4.6

Land and Soil Capability Classes in the Proposed Offset Sites

File Name (A4): R11/4004_251.dgn
20190515 11.02

Table 4.3 Soil and land resource units (based on OEH, 2018) in the proposed offset areas

SLR unit	Limitation to cultivation	Limitation to grazing	Mangoola (ha)	Wybong Heights (ha)	Total (ha)
Widden	Slight	Slight	21.2	8.7	29.9
Cranbourne	Slight to moderate	Slight	0	94.7	94.7
Bow	Moderate	Slight to moderate	0	8.4	8.4
Benjang	Moderate	Moderate	81.6	0	81.6
Sandy Hollow[1]	Moderate to high	Slight to moderate	505.4	46.3	551.7
Benjang variant A	Extreme	Moderate	14.6	0	14.6
Dunwell[2]	High to extreme	Moderate	41.3	6.1	47.4
Tingaroo[3]	High to very high	Moderate	210.0	105.8	3154.8
Tingaroo variant A	Extreme	Moderate	0	40.5	40.5
Donalds Gully	High to very high	Moderate to high	102.3	0	102.3
Galla Gilla	Very high	Moderate to high	0	152.3	152.3
Ant Hill	Very high to extreme	Moderate to high	0	53.3	53.3
Wingen Maid[4]	Extreme	High to extreme	28.69	244.8	273.5

[1] Please note that 86.9 ha of this SLR Unit are located inside the MCCO Additional Project Area, [2] Please note that 2.3 ha of this SLR Unit are located inside the MCCO Additional Project Area, [3] Please note that 97.9 ha of this SLR Unit are located inside the MCCO Additional Project Area, [4] Please note that 7.6 ha of this SLR Unit are located inside the MCCO Additional Project Area

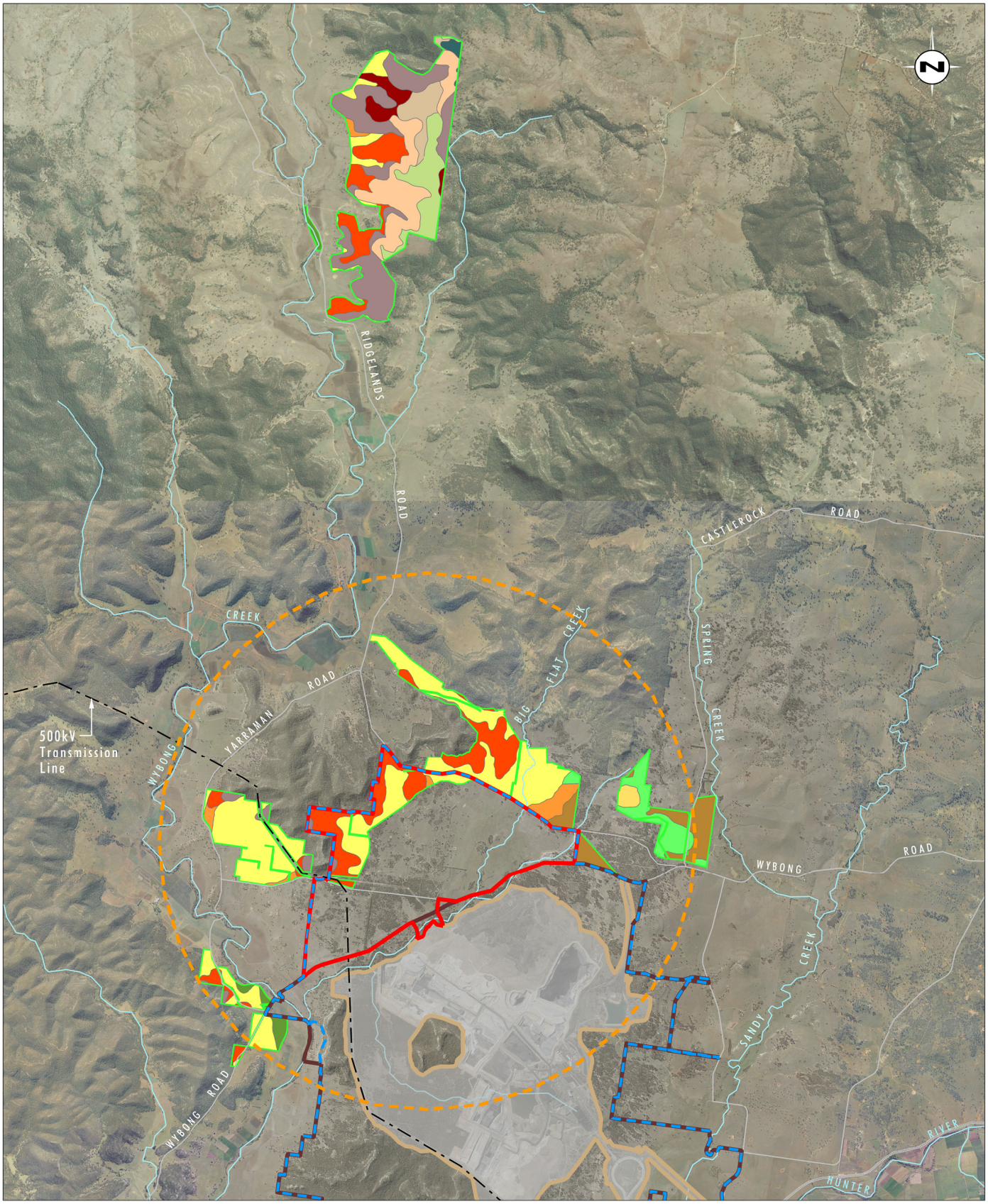


Image Source: Glencore (April 2018), Google Earth (Sept 2018)
Data Source: Glencore (2019)

0 1.0 2.5 5.0km
1:100 000

Legend

- MCCO Project Area
- Approved Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality
- Proposed Offset Site

Soil and Land Resources:

- Ant Hill
- Benjang
- Benjang variant a
- Bow
- Cranbourne
- Donalds Gully
- Dunwell
- Galla Gilla
- Sandy Hollow
- Tinagroo
- Tinagroo variant a
- Widden
- Wingen Maid

FIGURE 4.7

Soil and Land Resources in the Proposed Offset Sites

File Name (A4): R11/4004_236.dgn
20190515 11.52

A description for all SLR units except Bow, Cranbourne and Galla Gilla has been provided in **Section 3.3.** The additional three SLR units are discussed below (all information taken from OEH, 2018).

Bow

The Bow SLR unit occurs on gently undulating rises to undulating low hills. In the north west of the Hunter Region it can occasionally be found on gently inclined truncated footslopes and alluvial fans on Tertiary basalt. Slopes range from 2 - 10%, local relief. Soils of this SLR unit are shallow to moderately deep well-drained Dermosols and Ferrosols, moderately deep to very deep, moderately well to well-drained Black and Brown Vertosols and very shallow to shallow, well-drained Leptic Tenosols.

The SLR unit is mostly cleared woodland and open forest and is mainly used for cattle and sheep grazing on native pastures. Some longer footslopes and flatter areas are used for cropping. Land degradation is limited to minor streambank erosion along drainage lines. Limitations to grazing are rated as slight to moderate and limitations to cultivation are rated moderate.

Cranbourne

This SLR unit is associated with level plains to undulating rises comprised of plateaux and broad benches on Tertiary basalts. Slopes are less than 5% and local relief is low (<30 m). Soils are moderately deep to deep, moderately well-drained Haplic Mesotrophic Black Dermosols and Haplic Mesotrophic and Eutrophic Red Ferrosols, very shallow to shallow moderately well-drained Chernic-Leptic Tenosols and Leptic Rudosols and moderately deep to deep, imperfectly drained Haplic Self-mulching Red Vertosols.

The SLR is mostly used for light grazing with some cropping in accessible sites. Minor to moderate sheet erosion is apparent in grazing areas, with structural decline occurring in regularly cropped soils. Limitations to grazing are slight and limitations to cultivation are rated as slight to moderate.

Galla Gilla

This SLR unit can be found on steep low hills to very steep hills on Tertiary basalts. Slopes are steep with gradients exceeding 33%, the local relief ranges from 50 - 200 m. Soils are very shallow to moderately deep, moderately well-drained Leptic Tenosols and Rudosols and shallow to moderately deep, well to imperfectly drained Red and Black Chromosols and Dermosols.

The Galla Gilla SLR is mostly used for grazing on both native and improved pastures. Small areas support uncleared bushland. Sheet erosion is common for this SLR and mass movement is characteristic on steeper slopes with slumps and slides occurring on steeper slopes and bench edges. Terracetting occurs in conjunction with grazing practices on some steep slopes. Gully erosion occurs in areas of over-clearing, heavy stocking or where road and track culverts concentrate water. Limitations to grazing are moderate to high and limitations to cultivation are rated as very high.

The summary **Table 4.3** shows that cultivation and intense agriculture can only be carried out to a small portion (approximately 217 ha) of the Widden, Cranbourne, Bow or Benjang SLR units. The majority of SLR units in the proposed offset areas is unlikely to be suited to cultivation and intensive agriculture but suited for grazing purposes (approximately 1,010 ha) if appropriate management practices are in place (limitations to grazing moderate or less). A further approximately 308 ha would require more intensive management practices (moderate to high limitations). Areas with high to extreme limitations to grazing (approximately 267 ha) should not be used for agricultural purposes (**Table 4.3**, **Section 3.3** and Section above).

4.4.2.1 Strategic Agricultural Land

BSAL as well as Equine and Viticulture CICs have been mapped over parts of the proposed offset areas (**Figure 4.8**). BSAL is discussed below, Equine and Viticulture CICs are discussed in **Section 5.3.2**.

Wybong Heights, located approximately 8 km to the north of the MCCO Additional Project Area, has approximately 148 ha of BSAL mapped across it. A small area (<1 ha) is associated with the Wybong Creek floodplain, while a larger area of mapped BSAL occurs on a basalt plateau in the eastern extend of the proposed offset site (**Figure 4.8**).

Review of historic aerial imagery (since 2004) showed that cropping has previously occurred on the Wybong Creek floodplain, therefore it is assumed that the BSAL mapped along Wybong Creek has the potential to be productive agricultural land. The larger BSAL area was mapped on a plateau in the north-east of Wybong Heights. No evidence of cropping on this plateau was evident over the last 15 years. Field observations indicate that some areas of the plateau have a high occurrence of loose surface rock exceeding 60 mm in size (**Plate 4.1**). If areas have unattached rock fragments of 60 mm or larger over more than 20% of the area, they are not deemed to be BSAL (see **Table 4.1** criterion 3). No formal surface rock survey has been carried out, but it is expected that the area of BSAL on the plateau is smaller than mapped based on the surface rock criterion.

In addition to BSAL, the Widden SLR unit (8.7 ha), which has only slight limitations to cropping has been mapped along the Wybong Creek floodplain. The Cranbourne SLR Unit (94.7 ha), has slight to moderate limitations to cropping and is mapped on the plateau. Further, 8.4 ha of the Bow SLR unit (moderate limitations to cropping) has been mapped on the proposed Wybong Heights offset area (**Table 4.3, Figure 4.7**).

Plate 4.1 Loose surface rock in areas mapped as BSAL in Wybong Heights

The proposed Mangoola offset areas do not have any BSAL mapped across any of the properties. The Widden SLR unit (21.2 ha), however, only has slight limitations to cropping and the Benjang SLR unit (81.6 ha) has moderate limitations to cropping (see **Table 4.3**). These SLR units occur along the Wybong Creek floodplain (**Figure 4.7**).

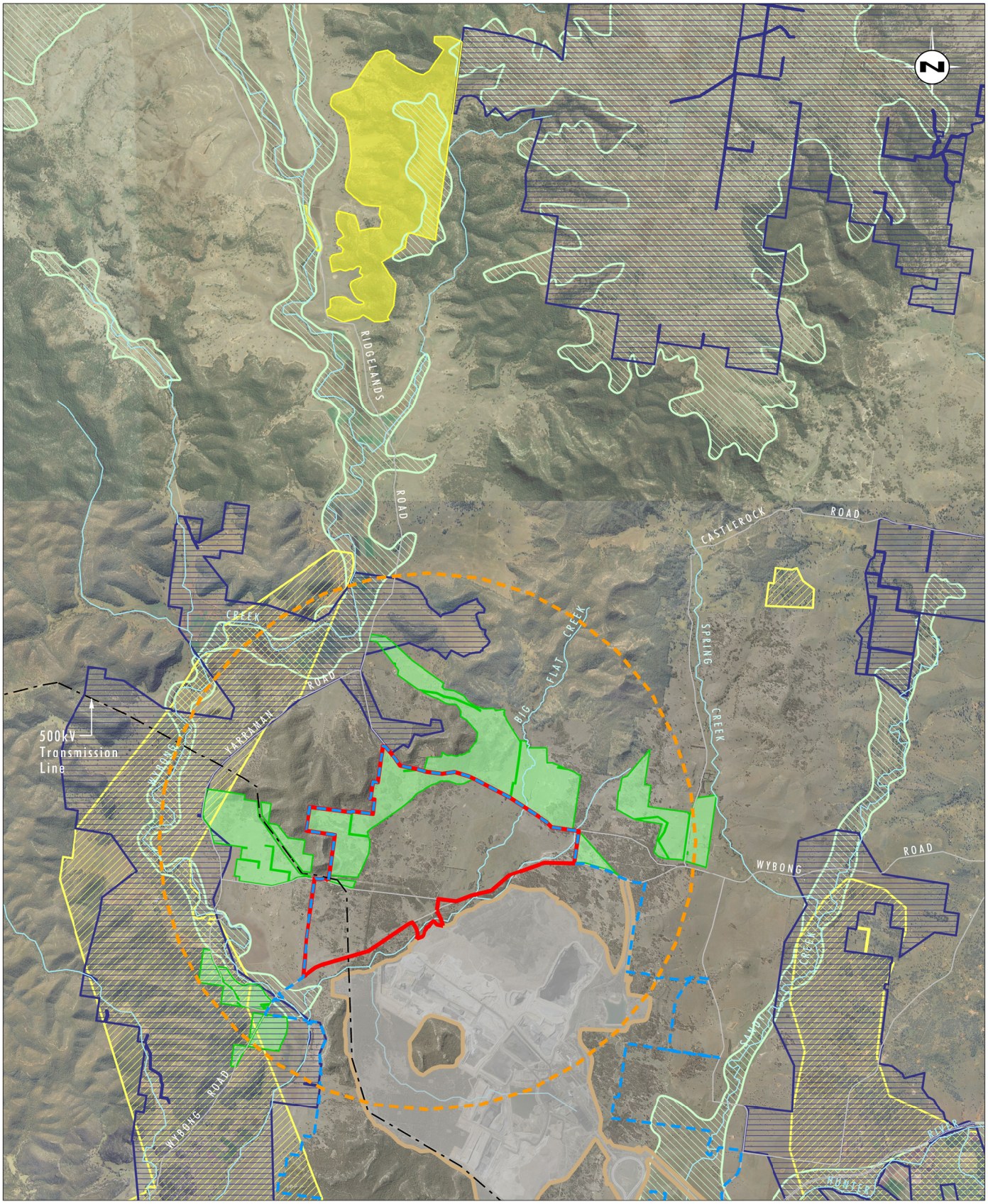


Image Source: Glencore (April 2018), Google Earth (Sept 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

0 1.0 2.5 5.0km
1:100 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Project Locality
- Proposed Mangoola Offset Sites
- Proposed Wybong Heights Offset Site

Strategic Regional Land Use Policy (SRLUP):

- Biophysical Strategic Agricultural Land
- Equine Critical Industry Cluster
- Viticulture Critical Industry Cluster

FIGURE 4.8

Biophysical Strategic Agricultural Land and Critical Industy Clusters for the Proposed Offset Sites

File Name (A4): R11/4004_237.dgn
20181116 14.17

5.0 Agricultural Industries and Productivity of the MCCO Additional Project Area and Locality

5.1 Land Ownership in the Locality

Land ownership of the MCCO Additional Project Area and the surrounding locality is shown in **Figure 5.1**. All land (within the exception of some road reserves and Crown land) and residences within the MCCO Additional Project Area are owned by Mangoola. In the project locality, the land owners include Mangoola, Crown Land and a range of private landholders.

5.2 History of Agriculture

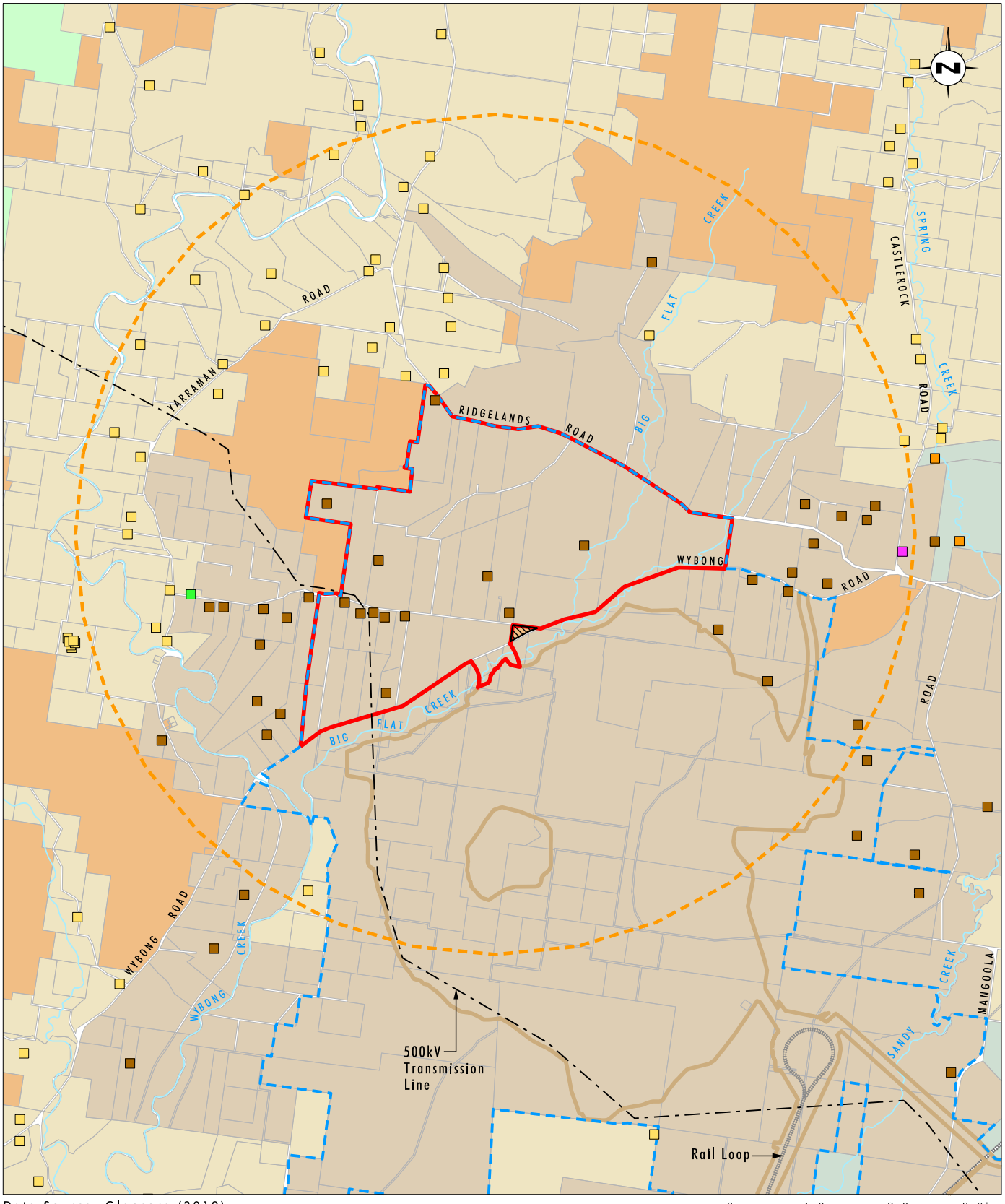
The history of European settlement in the upper Hunter region dates to the 1820s. Since that time, a wide range of agricultural and rural activities have been practiced on land cleared for farming. The thoroughbred industry has been established in the Upper Hunter Valley for over 150 years. The diversity of the agricultural activities in the region reflects the variability of local climate; the contrasting land and soil capability of the best alluvial creek flats and steep sandstone escarpment country; the impact of invasive species on vulnerable land; and the impact of both technology and national scale economic change. Although there is wide diversity, the core agricultural land uses continuing to the present day are beef cattle grazing, horse breeding, vineyards and specialist horticulture.

The information presented in this section is based on the Historical Heritage Assessment completed as part of the MCCO Project EIS.

5.2.1 Regional history

From the time of British settlement of New South Wales, all land ownership was vested in the Crown. Land in the Goulburn River catchment of the Upper Hunter, including along Wybong Creek, was taken up by British settlers from about 1825, initially under a policy of free land grants. The earliest agricultural uses of the land around the Project Area dates to this period.

In 1831 the British Government passed an Act which allowed the sale of Crown land in New South Wales and ceased to provide free grants of land. At the same time the Government allowed the leasing of Crown land annually.



Data Source: Glencore (2019)

0 1.0 2.0 3.0 km
1:65 000

Legend

- MCCO Project Area
- Approved Mangoola Coal Mine Disturbance Area
- MCCO Additional Project Area
- Crown Land (TSR) Excluded from MCCO Project Area
- Project Locality
- Crown Land
- Mangoola Owned Land
- Other Mined Owned Land
- Private Land
- Nature Reserve
- Church
- Mangoola Owned Residence
- Other Mine Owned Residence
- Private Residence
- Wybong Hall

FIGURE 5.1

Land Ownership

File Name (A4): R11/4004_246.dgn
20190506 15.55

5.2.2 Local history and Historical Land Uses of Wybong

The first person to select land in the Parish of Wybong was Charles Hunter McIntosh. He took possession of 640 acres on the east bank of Wybong Creek on 21 September 1827. It is unknown if McIntosh settled on his block or if he leased it out. The land was granted on 30 September 1834 and in 1836 McIntosh sold it to John Pike.

John Pike was one of the original settlers in the Denman area. His base station was 'Pickering' located approximately 5 km north of Denman, but John Pike took up a number of blocks along the Goulburn River and Wybong Creek under lease and purchase. Pike received deeds for two 640 acres blocks in the Parish of Wybong on 5 January 1841. Pike was the sole owner of land within the Parish of Wybong until 16 April 1859 when he sold some land to Henry Nowland of Muswellbrook.

Before 1861, there had only been three owners of freehold land within the Parish of Wybong, namely Charles H McIntosh, John Pike and Henry Nowland. Legislative changes in 1861 introduced conditional land purchase, paying a deposit and paying off the land in annual instalments. Following this, settlers moved into the area and resulted in an increase of Wybong Land settlers.

In 1885, grazing of horses, cattle, sheep and pig were carried out in the Wybong area on properties owned by 16 people (**Table 5.1**). 80% of the properties were less than 200 ha, with small numbers of livestock (horses, cattle and pigs). There was one sheep farmer, who ran 300 sheep on his 560 ha property.

By the end of the 19th century, most of the Crown land in the Parish of Wybong had been taken up. In 1906, the Shire of Wybong was formed.

World War 2 led to the increase of settlement within Wybong with returning soldiers being encouraged to settle in the area.

Table 5.1 Wybong land settlers' land use in 1885

Name	Acres	Horses	Cattle	Sheep	Pigs
M Cody	80	2	5		2
C McTaggart	660	12	10		1
T Hogan	40	8	16		1
W Bates	560	9		300	
J Clark	200	14	24		3
EC Googe	40	5	7		2
JJ Googe	170	5	5		
John Googe	80	1	4		3
E Sweeney	130	0	20		
J McHugh	80	3	14		1
J Galvin	140	10	11		
J Maloney	80	12	4		

Name	Acres	Horses	Cattle	Sheep	Pigs
P Quinn	150	10	6		7
J McHugh Snr	80	4	15		2
M Flanagan	620	16	35		4
J Sellings	160	2	5		2

5.2.3 History of Agricultural Industries of the Upper Hunter and Wybong

Dairying was one of the initial motivations for the division of large estates in the Upper Hunter. The 1828 census indicates that, on the 191 large (over 1,000 acre) estates occupying the Upper Hunter Valley, cattle raising was much more common than sheep grazing. By the 1890s dairying had become an important industry in the Upper Hunter and in 1893 a creamery was established at Kayuga. In 1903 the creamery at 'Overton' was set up by Thomas Blunt, and the Denman Co-operative Dairy Company was founded in 1907.

Timber cutting was common in the Upper Hunter Valley through the late 19th century and early 20th century. Timber was being used for mining props and commercial sale and was also used for charcoal retorts during World War II on the northern bank of Big Flat Creek. Rabbiting was also an important industry from the beginning of the twentieth century during the Depression years, until the introduction of myxomatosis in the 1950s. Rabbits were destructive to the environment and increased erosion of the natural topsoil. Ripping for rabbits also lead to the destruction and disturbance of the natural environment. Rabbit canning and freezing works were established in Muswellbrook during the early twentieth century.

Vineyards existed in the Upper Hunter Valley in 1829 at Pickering and Bengalla. In the 1850s, vineyards declined when the larger estates were broken up and changed hands. Free settlers mainly used the land for graziers. The exception was the Brecht Brothers who developed a large vineyard at Rosemount near Myambit. The vine industry was destroyed by an outbreak of the pest insect Phylloxera in 1910 which lead to vineyards being dug up to destroy the bug from spreading. It was not until the 1960s that winemaking was redeveloped and earlier traditions revived including the development of the Penfolds Estate at Dalwood.

Vineyards were an important industry which still remains visible in the region, however, only Yarraman and Wybong Estate Vineyard are still present in the locality and the Yarraman vineyards appeared nonoperational.

5.3 Agriculture in the MCCO Additional Project Area, Locality and Muswellbrook LGA

This section describes the contemporary rural land use in the MCCO Additional Project Area, the locality and the Muswellbrook LGA.

5.3.1 Farming in the MCCO Additional Project Area

The MCCO Additional Project Area, excluding the steeply sloping area of LSC 7 land, is used for cattle grazing. Several small, abandoned olive groves are present in the area. Three of these are too young to have produced olives. Considerable grazing pressure is evident on young trees (**Plate 5.1**) and older trees would require pruning.

Plate 5.1 Young, non-productive olive orchard in the MCCO Additional Project Area

The Colinta Pastoral Company (Colinta) manages the MCCO Additional Project Area as well as Mangoola's other farming land. In average years, Colinta runs 850 breeders on the Mangoola farming land, 350 of which are grazed in the MCCO Additional Project Area. However, due to the very dry conditions through 2016 to 2018, the stocking rate on the MCCO Additional Project Area was reduced to 200 breeders by January 2018.

Due to the ongoing drought in 2018, further reductions of the herd size were undertaken throughout the year and the MCCO Additional Project Area was fully destocked in August 2018. By November 2018, the total Mangoola herd was reduced to 400 breeders, which were run on Mangoola's southern grazing land.

In average years, no extra feed is required for the MCCO Additional Project Area, but the 2018 drought resulted in the need to buy supplementary feed and stock on the MCCO Additional Project Area were hand-fed for all of 2018 until the destocking in August. This was the first time additional feed was required during the 10 year management of the land by Colinta. In October 2018, of the remaining 400 head of breeders on Mangoola farming land, 100 head were hand-fed, while the remaining cattle did not require supplementary feed due to better productivity of the southern grazing land.

The MCCO Additional Project Area is not fertilised and water is supplied through surface dams. No degradation of land, through salinity, erosion or other factors has been observed.

Colinta managers have reported that the biggest driver for the grazing industry in the MCCO Additional Area is the beef prices, whereas environmental factors generally do not impact production. Generally, 310 calves per year are being turned off the MCCO Additional Project Area. These calves are subsequently sent to Mangoola Coal owned cropping areas on the Hunter River for fattening before being shipped to a feedlot or saleyard in the region.

5.3.2 Farming in the Proposed Offset Areas

The proposed offset sites, including both Mangoola area and Wybong Heights are owned by Mangoola/Glencore and currently managed as grazing land by Colinta.

Approximately 150 head are run on the proposed Mangoola offset area, excluding the MCCO Additional Project Area. Like the MCCO Additional Project Area, destocking took place between June and August 2018 because of the severe drought conditions. Prior to destocking, additional feed was required through most of 2018. Watering of the stock occurs through surface dams, with the exceptions to areas where there is direct access to Wybong Creek.

Historically, some cropping has occurred in small areas in the proposed offset areas and a small olive orchard (approximately 3 ha) is present along Ridgelands Road. The orchard area is currently used as grazing land and no olive production occurs (**Plate 5.1**).

Both Equine and Viticulture CICs are mapped in the proposed Mangoola offset area. The Viticulture CIC (approximately 74 ha) is located in the westernmost proposed offset area along the between the Wybong Creek floodplain and the rolling hills, as well as in a north-western part of the proposed offset area, mainly situated in the rolling hills (**Figure 4.8**).

There are no vineyards in the proposed offset areas. Aerial images showed that a vineyard was present in parts of the proposed western offset area along Yarraman Road in 2004 (approximately 6 ha). This vineyard appeared to be in bad condition in 2009 and there is no evidence of this vineyard in aerial photos taken since 2013. No evidence of grape farming was evident in the north-western part of the proposed offset area since 2004.

Approximately 116 ha of Equine CIC is mapped in the western and north-western parts of the proposed Mangoola offset area (**Figure 4.8**). No horse studs occur in the proposed offset areas currently or have been known to occur historically.

In non-drought years, approximately 140 head of cattle are run on the proposed Wybong Heights offset area. Circa 60 head are run on the basalt plateau and 80 head along the Wybong Creek floodplain, of which only a small area is proposed for biodiversity conservation. While cattle have access to the vegetated hillslopes, these have limited value for grazing compared to the plateau and floodplain.

Due to the current drought, the herd has been reduced to 75 head as the dams and well on the plateau have run dry. Wybong Creek is providing access to water and cattle move freely between the creek and the plateau. Hand feeding has been carried out in late 2018 and stopped in the first two months of 2019.

No Equine or Viticulture CICs have been mapped for the proposed Wybong Heights offset area.

5.3.3 Farming in the Locality

There are 862 ha of Viticulture CIC mapped across the locality, including the proposed offset areas. The Wybong Estate Vineyard, which is part of the Hollydene Estate Wines, is located in the north western extent of the locality. The vineyard was established in 1965 with 35 acres of a range of grape varieties growing today. A further planting of five acres is planned according to the operator[6]. This is the only operating vineyard in the area.

Yarraman Estate is situated at the western extent of the locality. This winery was the oldest winery and vineyard in the Upper Hunter Valley, being established in 1958. The winery was put into administration in

[6] https://hollydeneestate.com/pages/wybong-vineyard, accessed 07/02/2019

2011 and sold in 2015. During a drive by inspection undertaken for this assessment in December 2017 the vineyard was observed to not be in production and the established vines appeared to have died. A feedlot development has been proposed on the site for which SEARs have been received (KMH, 2016) (see **Section 5.3.6**).

There are approximately 1,407 ha of Equine CIC mapped in the locality. There are no horse studs in the locality, Coronet Farm, a small horse stud, is located just outside of the locality off Dry Creek Road. This horse stud is to the north-east of the MCCO Additional Project Area and thus separated from it by steep hills. The Golden Grove Thoroughbred horse stud is situated approximately 5 km south-west of the locality. A former equine business, Nightingale Thoroughbreds was located to the immediate north of the MCCO Additional Project Area off Ridgeland's Road however it is noted that this has not been operational since 2012.

There are approximately 434 ha of BSAL mapped in the locality. Cattle grazing is the dominant land use in the locality, both on improved pasture and native pasture. Many of the areas shown as cropping land, both on historic aerial imagery and the NSW 2013 land use mapping (NSW Government, 2018), were not under cropping when a site visit was undertaken in December 2017. The government land use mapping is based on 2013 SPOT5 (satellite) imagery and has been carried out at a 1: 10 000 scale. Based on historic aerial imagery, the land use mapping and BSAL mapping, it is assumed that areas along the Wybong Creek are intermittently used as cropping areas (e.g. for fodder crops), depending on seasonal conditions.

One small, privately owned and operated olive orchard, 3 ha in size, is located on Ridgelands Road approximately 2 km to the north of the MCCO Additional Project Area. A second olive orchard (1.5 ha in size) is located on Glencore owned land, however is no longer in production. Lucerne, approximately 4 ha, was cropped in the northern extent of the locality at a property located approximately 2 km to the north-west along Dry Creek Road and recently worked fields were located on the other side of Wybong Creek (**Plate 5.2** and **Plate 5.3**, respectively).

Plate 5.2 Lucerne cropping at Dry Creek Road

Plate 5.3 Grazing along Dry Creek Road (foreground) and recently worked field in the background beyond Wybong Creek

The approved Mangoola Coal Mine takes up large areas of the southern part of the locality. All Mangoola owned land, which is not used for mining purposes, is either maintained as part of the existing offset commitments as conservation lands or is managed by Colinta and used for cattle grazing as discussed in **Section 5.3.1**. Colinta does not use any land in the locality for irrigated cropping.

5.3.4 Muswellbrook LGA

The Muswellbrook LGA has a size of approximately 340,488 ha, of which approximately 144,598 ha, or 42.5%, are protected areas (ABS, 2017a). In 2015-2016, the area of farm holding was 122,674 ha, or 36% of the LGA area. The total area of farm holdings was virtually unchanged between 2001 and 2016, with a decrease in area between 2006 and 2011 and a subsequent increase between 2011 and 2016. This decrease could be the result of the severe Millennium drought which occurred from late 1996 to mid-2010. Farm land, which may not have been viable for farming during the drought years, may have been taken back into operation after the drought broke in mid-2010, which may account for the increase in farm holdings between 2010-2011 and 2015-2016 (**Table 5.2**).

While holding areas remained similar, the number of farms continuously decreased from 2006 to 2016 (**Table 5.2**). This is mirrored by a general decrease of the number of businesses in agriculture, forestry and fishing between 2006 (372 businesses) and 2015 (310 businesses) (ABS, 2010a, ABS, 2017b). In 2011, 7.1% of the workforce was employed in the agricultural sector (ABS 2017a).

Table 5.2 Land Use by Area for Agriculture in the Muswellbrook LGA, 2000-2001, 2005-2006, 2010-2011 and 2015-2016 data

	Census date			
	2000-2001[a]	2005-2006[b]	2010-2011[c]	2015-2016[d]
LGA Area (ha)	340,200	340,200	340,200	340,488
Area of farm holdings (ha)	122,272	121,872	105,548	122,674
Change of area of farm holdings		-400	-16,324	17,126
Number of farms	271	314	264	169
Change in number of farms		43	-50	-95
Farm holdings as percentage of LGA area	36%	36%	31%	36%
Change farm holdings as percentage of LGA area (%)		0	-5	5
Crop and grazing land (ha)	65,013	101,702	94,829	NA
Crop land (including fallow) (ha)	5,088	6,256	6,653	3,710
Grazing land (ha)	59,925	95,446	88,176	NA
Changes in crop land (ha)		1,168	397	-2,943
Changes in grazing land (ha)		35,521	-7,270	

*Data sourced from: [a] ABS, 2008a, [b] ABS, 2008b, [c] ABS, 2012a, [d] ABS, 2017c

The area used for cropping remained stable between 2006 and 2011, but decreased by over 50% by 2016. Grazing land increased markedly between 2001 and 2006 and slightly decreased in the period thereafter (**Table 5.2**).

Agriculture in the Muswellbrook LGA encompasses a range of commodities, the most important being livestock, both for slaughter and livestock product. In decreasing significance, livestock for slaughter includes cattle and calves, poultry, sheep and lambs, pigs and goat. Milk production is the central livestock production commodity, with wool and egg production also occurring.

The most important crop production in the LGA is hay and silage production. Further agricultural commodities are broadacre crops, fruit and nuts, grapes, vegetables for human consumption, as well as nurseries and cut flowers.

The Australian Bureau of Statistics (ABS) estimates the value of agricultural commodities as local value and gross value. The former is the price that would be paid at the farm gate, the latter the price in the wholesale market. For the purpose of this AIS, gross values have been used.

In 2015-2016, Muswellbrook LGA accounted for approximately 9% of the value of the Hunter Valley (excluding Newcastle) agricultural sector and less than 1% of NSW agricultural sector (**Table 5.3**).

Table 5.3 Estimated Value of Agricultural Products for Muswellbrook LGA, Hunter Valley (excl Newcastle) and New South Wales in 2015-2016

Location	Estimated Value of Agricultural Products 2015-2016 ($m)
Muswellbrook LGA	33.2
Hunter Valley excluding Newcastle	362.1
NSW	13,085.8

Source ABS, 2017d

Some agricultural commodities have a larger percentage of the Hunter Valley (excluding Newcastle) agricultural economy for each commodity. Almost half of the Hunter Valley estimated gross value for fruits and nuts (excluding grapes) is derived in the Muswellbrook LGA, as is almost a quarter of the hay and silage gross value and 22% of the grape value. However, while the percentage of the value derived in Muswellbrook is sizable, the monetary value of these commodities is comparatively small compared to the value derived from farming cattle for slaughter or livestock product (**Table 5.4**).

Table 5.4 Estimated gross value for agricultural commodities in Muswellbrook LGA and Hunter Valley excl. Newcastle in 2015-2016.

Agricultural Commodity	Estimated Value of Agricultural Products Muswellbrook LGA ($m)	Estimated Value of Agricultural Products Hunter excl Newcastle ($m)	Percentage Value Muswellbrook LGA of Hunter excl Newcastle (%)
Total agriculture	33.16	362.09	9%
Total value of crops	5.07	31.46	16%
Broadacre crops	0.34	6.96	5%
Hay and silage	3.86	16.19	24%
Fruit and nuts (excluding grapes)	0.45	0.92	49%
Fruit and nuts - Grapes	0.41	1.87	22%
Livestock products - Total	7.44	74.29	10%
Livestock Products - Wool	0.18	8.02	2%
Livestock products - Milk	7.18	41.90	17%
Livestock products - Eggs	0.07	24.37	<1%
Livestock slaughtered - Total	20.65	256.35	8%
Livestock slaughtered - Sheep and lambs	0.16	5.23	3%
Livestock slaughtered - Cattle and calves	19.87	166.40	12%

Agricultural Commodity	Estimated Value of Agricultural Products Muswellbrook LGA ($m)	Estimated Value of Agricultural Products Hunter excl Newcastle ($m)	Percentage Value Muswellbrook LGA of Hunter excl Newcastle (%)
Livestock slaughtered - Goats	< 0.00	0.24	<1%
Livestock slaughtered - Pigs	0.01	1.28	<1%
Livestock slaughtered - Poultry	0.62	83.20	<1%

Source ABS, 2017d

Table 5.5 and **Table 5.6** present the agricultural production data and estimated gross value for Muswellbrook LGA in the last ten years (2005-2015). As some of the agricultural commodities were not reported on in 2015/2016, data from 2010/2011 have been included as well.

The gross value of the total agriculture in the Muswellbrook LGA has declined over the last ten years. In 2005/2006 the gross value of agriculture was $34m, while ten years later it decreased to $33.2m (**Table 5.5**). According to the Reserve Bank of Australia (RBA), $33m in 2005/2006 is equivalent to approximately $44.1m in 2015/2016. The 2010/2011 gross value of the agricultural sector, increased almost in line with inflation (actual gross value $38.0m, gross value equivalent of 2005/2006 after inflation $39.3m). The decrease in gross value of the total agriculture could be due to a strong shift away from livestock products to livestock slaughtering in 2015/2016. This follows a marked decrease in average Australian farm gate milk price in 2008/2009. However, the decrease in farm gate milk price for the NSW market was less pronounced (Rural Bank, 2017).

The relative importance of broad-acre crops, hay and silage production and fruit and nut production for total agricultural value remained stable over the last ten years (**Table 5.5**), even though tonnes of silage produced increased by almost 30% (**Table 5.6**).

Grape production and income generated through viticulture decreased markedly over the last decade. In 2005/2006 a total of 9,330 t of grapes were produced with an average yield of 6.5 t/ha. Grape production decreased by approximately 70% in 2010/2011 to 2,819 t with an average yield of 3 t/ha and by a further 56% in 2015/2016 (**Table 5.6**). The reduction in grapes may partly be caused by the grape oversupply between 2000 and 2008, which coincided with a high Australian dollar impacting export market demands (DPI, 2013b).

Table 5.5 Gross Value of selected agricultural commodities in the Muswellbrook LGA in 2005-2006, 2010-2011 and 2015-2016.

Agricultural Commodity	2005/2006		2010/2011		2015/2016	
	Gross Value ($m)[a]	% of total agriculture	Gross Value ($m)[b]	% of total agriculture	Gross Value ($m)[c]	% of total agriculture
Total agriculture	34.0		38.0		33.2	
Broadacre crops	0.2	0.6	0.3	0.8	0.3	1.0
Hay and silage	4.0	11.6	3.8	10.0	3.9	11.6
Nurseries and cut flowers	0.1	0.3	0.1	0.3	No data	
Fruit and nuts - Grapes	4.2	12.4	0.9	2.4	0.4	1.2
Fruit and nuts - (excluding grapes)	1.1	3.3	1.1	2.9	0.5	1.4
Livestock products • Wool • Milk • Eggs	13.1 • 0.1 • 13.1 • 0.0	38.6 • 0.2 • 38.4 • 0.0	16.6 • No data • 16.6 • No data	43.7 • No data • 43.7 • No data	7.4 • 0.2 • 7.2 • 0.1	22.4 • 0.5 • 21.7 • 0.2
Livestock slaughtering • Sheep • Cattle • Poultry	11.3 • 0.1 • 11.1 • 0.1	33.0 • 0.4 • 32.5 • 0.2	15.2 • No data • 15.1 • 0.1	40.0 • No data • 39.7 • 0.3	20.7 • 0.2 • 19.9 • 0.6	62.3 • 0.5 • 59.9 • 1.9

Data source: [a] ABS, 2008c; ABS, 2008d; ABS, 2008e; ABS, 2008f, [b] ABS, 2012b, [c] ABS, 2017d

Table 5.6 Annual yield and livestock numbers in the Muswellbrook LGA in 2005-2006, 2010-2011 and 2015-2016.

Agricultural Commodity	2005/ 2006[a]	2010/ 2011[b]	2015/ 2016[c]	5 year change		10 year change
				2005/ 2006- 2010/ 2011	2010/ 2011- 2015/ 2016	2005/ 2006 - 2015/ 2016
Broad-acre crops (t)	417	835	1247	418	412	830
Hay and silage (t)	19,976	16,707	29,215	-3269	12,508	9,239
Vegetables for human consumption (t)	138	35		-103		

Agricultural Commodity	2005/ 2006[a]	2010/ 2011[b]	2015/ 2016[c]	5 year change		10 year change
				2005/ 2006- 2010/ 2011	2010/ 2011- 2015/ 2016	2005/ 2006 - 2015/ 2016
Fruit and nuts - Grapes (t)	9,330	2,819	1,229	-6,511	-1,590	-8,101
Fruit and nuts - (excluding grapes) (t)	233	444		211		
Sheep and lambs (no)	2,517	2,957	5,006	440	2,049	2,489
Total Cattle and calves (no)	46,166	45,046	38,748	-1,120	-6,298	-7,418
Dairy cattle (no)	10,421	10,546	3,484	125	-7,062	-6,937
Meat cattle (no)	35,745	34,500	35,264	-1,245	764	-481
Pigs (no)	1,211	16	16	-1,195		-1,195
Poultry (no)	1,115	3,372	1,695	2,257	-1,677	580
Goats (no)	374	128	43	-246	-85	-331

Data source: [a] ABS,2008g; ABS, 2008h, [b] ABS, 2012a, [c] ABS, 2017c

The importance of livestock, both for product and for slaughter, for agriculture has increased from a combined 71.6% in 2005/2006 to 85.7% in 2015/2016. In 2005/2006 and 2010/2011, livestock product and livestock for slaughter had a similar share of the agricultural gross value, whereas in the latest survey, the importance has shifted towards livestock for slaughtering (**Table 5.6**). The number of dairy cattle has decreased by over 60% in the last decade, which was accompanied by a strong decrease in gross value of milk production (**Table 5.5**, **Table 5.6**). This decrease exceeded the decrease of dairy cattle in NSW, which fell by approximately 30% between 2005/2006 and 2015/2016.

During 2015/2016, almost 60% of the total agricultural gross value was produced by meat cattle, which is approximately double the value percentage of 2005/2006. Over the last ten years, meat cattle numbers have not changed greatly. The large percentage of cattle for slaughter of the total gross agricultural value is partly due to the decrease of the total agricultural value, however, total value of cattle for slaughter has increased as well (**Table 5.5**, **Table 5.6**).

The higher percentage of gross value from cattle breeding and slaughtering in the Muswellbrook LGA is in line with the importance of the meat cattle industry in the Upper Hunter Region (DPI, 2013d).

The full economic significance of horse studs in the Upper Hunter generally, and specifically in Muswellbrook LGA is not comprehensively reported by ABS (DPI 2013). However, the Upper Hunter is known nationally and internationally as an important thoroughbred breeding region (DPI 2013), with a strong reputation for the quality of the bloodlines. Studs attract high fees for servicing, rearing and agisting quality stock and the industry has extensive flow on values for employment in support services.

Value from the horse industry is generated through horse breeding, horse racing and indirectly through the value of tourism associated with horse studs in the Hunter Valley. The horse industry covers a range of

breeds, including draught, polo, racing and recreational horses. Generally, the horse industry is deemed critical to the economy of the Muswellbrook LGA (DPI, 2013f).

Stud horse numbers, when reported through ABS in 2005/2006 and 2010/2011 increased by approximately 30%. In the Hunter Valley and NSW, on the other hand, stud horse numbers decreased between 2005/2006 and 2010/2011. Stud horses in the Muswellbrook LGA made up 21.7% and 34.5% of all stud horses in the Hunter Valley in 2005/2006 and 2010/2011, respectively. The relative importance of the Muswellbrook LGA compared to the state of NSW was 6.9% (2005/2006) and 10.5% (2010/2011). The number of studs in the Muswellbrook LGA remained constant in the reported time period, whereas there was a slight decline of studs in the Hunter Valley (**Table 5.7**).

No information for horse breeding for the 2015/2016 ABS survey was available.

Table 5.7 Numbers of horses in the Muswellbrook LGA, Hunter Valley and NSW in 2005/2006 and 2010/2011

ABS survey date	Commodity	Muswellbrook LGA	Hunter Valley	NSW	Proportion Muswellbrook LGA on	
					Hunter Valley	NSW
2005/2006[a]	Horses – Stud (no)	2,630	12,120*	38,356	21.7%	6.9%
	Stud businesses (no)	38	356*	2,430	10.7%	1.6%
	Horses – Other (no)	605	7,004*	49,917	8.6%	1.2%
	Horse other businesses (no)	108	1,210*	10,064	8.9%	1.1%
2010/2011[b]	Horses – Stud (no)	3,546	10,285[+]	33,632	34.5%	10.5%
	Stud businesses (no)	38	295[+]	2,448	12.9%	1.6%
	Horses – Other (no)	517	5,966[+]	53,679	8.7%	1.0%
	Horse other businesses (no)	99	970[+]	10,660	10.2%	0.9%

* Statistical Division Hunter, [+] Hunter Valley excluding Newcastle
Data source: [a] ABS, 2008h, [b] ABS, 2012a

5.3.5 Agricultural Communities

Farm holdings make up 36% of the Muswellbrook LGA area, but only 7.1% of the working population was employed in the agricultural sector. Of this, 3% were working in the horse farming industry[7]. Coal mining on the other hand accounted for 20% of the working population in 2016, which has increased from 13.8% in 2006[8] and 18.5% in 2011[9].

Table 5.8 presents farm demographics in the Muswellbrook LGA (Region plus Town) in 2015/2016. In the Muswellbrook LGA, there are approximately 145 people who work on the farm they own. However, only 14 employees or contractors are working on farms in the LGA and four workers were neither the owner nor an employee on the farm they worked. The majority of the income of the farm workers is derived from farming (**Table 5.8**).

The average age of the farm worker in Muswellbrook Region and Town is 59 years and 61 years, respectively. This indicates a strongly aging workforce. This is consistent with the average age of farm workers in the Hunter Valley (excl. Newcastle) and NSW. In the Muswellbrook Region, 20% of the income of farm workers is generated by employment or activities outside of the farm, which is also found to be the case in the Hunter Valley (excl. Newcastle) (19%) and slightly above the percentage recorded for NSW (13%) (**Table 5.8**). DPI (2013) note that, at that time, there was a shortage of skilled farm workers in the Upper Hunter region. This is attributed to strong alternative employment opportunities (such as the mining sector and service industries) and is consistent with the high off-farm income of farm workers.

It is noted that the 2016 census was undertaken in May, and as a result many seasonal picking and pruning employment options are not captured by the data presented.

[7] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/LGA15650?opendocument, accessed 08/02/2019

[8] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2006/quickstat/LGA15650?opendocument, accessed 08/02/2019

[9] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/LGA15650?opendocument, accessed 08/02/2019

Table 5.8 Farm demographics in the Muswellbrook LGA

Description	Muswellbrook Region	Muswellbrook Town	Hunter Valley (excl Newcastle)	NSW
Owner operator (no)	129	16	973	23,216
Contractor/employee (no)	14	np	79	917
Other relationship to business (no)	4	np	48	832
Males (no)	106	12	820	19,718
Females (no)	37	7	292	5,512
Average age - all persons (yrs)	59	61	59	57
Age of male provider - Average age (yrs)	61	60	60	58
Age of female provider - Average age (yrs)	52	62	57	56
Years involved in farming - Average years (yrs)	36	43	36	36
Income generated by agricultural production on holding - Average percentage (%)	75	82	75	82
Income through grants, government transfers, relief funding - Average percentage (%)	np	0	1	<1
Income generated by off-farm employment/business activities - Average percentage (%)	20	np	19	13
Other funding sources - Average percentage (%)	np	np	5	4
Income source not stated - Average percentage (%)	0	0	1	<1

np – not available for publication
Data source: ABS, 2017e

5.3.6 Supporting Infrastructure

A well-developed road network connects the locality to markets, services and suppliers. Road services range from the New England Highway and Golden Highway to local sealed and unsealed roads. The Muswellbrook to Ulan freight rail line runs south of the locality and enables train connections to Sydney and Newcastle. The main agricultural service centre is Muswellbrook, with Singleton and Scone being located within an hour driving distance from the locality.

Livestock farming for slaughter has the highest importance for agriculture in the Muswellbrook LGA, whereas farming of livestock for product, such as dairy, has been rapidly declining (**Table 5.5**).

Regional livestock saleyards are located in in Scone, Singleton, Maitland and Mudgee. The closest abattoirs to the MCCO Additional Project Area are situated in Scone and Singleton. Additional abattoirs can be found in Dubbo, Tamworth and Sydney.

Further, an abattoir and feedlot facility (Yarraman Abattoir and Feedlot) is proposed in proximity to the locality. The proposed feedlot would be situated on the Yarraman Property in the west of the locality, while the abattoir would be situated close to Hollydeen. This facility is intended to process 500,000 head of cattle and 1,000,000 head of sheep per year (KMH, 2016). SEARs for this proposal were issued in 2016 (DPI, 2016). The proponent of the Yarraman Abattoir and Feedlot stated that the adjacent Mangoola Coal Mine and related buffer land not used for mining is beneficial for the abattoir and feedlot projects[10].

In 2013, the majority (90%) of dairy produced in the Upper Hunter Region was processed in Sydney, with the remainder being processed in Hexham and on the North Coast (DPI, 2013e). This reinforces the importance of a high quality road network for the dairy industry.

[10] https://www.theherald.com.au/story/3885391/abattoir-jobs-could-fill-coal-void/

6.0 Assessment of Impacts

The potential impacts from mining activities on the land resources and agricultural productivity generally can vary from temporary to long term and permanent. Temporary impacts can include the construction of access tracks or storage of topsoil resources, as well as operational impacts such as noise and air quality. Long term impacts may include changes to water availability and the future land and soil capability of reshaped overburden placement areas. Permanent impacts are irreversible and do not allow the reinstatement of the pre-mining land and soil capability or agricultural uses. They can include final voids and significant changes to the pre-mining landform, drainage patterns or groundwater quality and quantity. The nature and scale of impacts vary between mining projects and the predicted impacts of the MCCO Project are discussed below.

The scope of potential impacts on agricultural resources and agricultural enterprises includes:

- Direct and permanent loss of agricultural land and resources in the Proposed Disturbance Area for domains (disturbance areas) which will not be rehabilitated to post mining agricultural land use.
- Direct, temporary loss of agricultural land and resources in the Proposed Disturbance Area of domains that will be rehabilitated for an agricultural post mining land use.
- Permanent change in land use within the proposed biodiversity offset areas. While there will not be any direct, negative impacts to the agricultural resource, the land is proposed to be permanently taken out of agricultural production due to its high value as conservation land.
- Potential indirect impacts on agricultural land and enterprises due to environmental impacts such as dust, noise and changes to surface or groundwater quality or quantity. These impacts can vary from being non-existent to negligible to significant and may be temporary (generation of noise or dust) or long term (i.e. impacts to groundwater levels).
- Indirect impacts to agricultural enterprises due to altered access roads. These impacts are generally temporary.
- Indirect impacts on nearby communities due to changes in demand on the work force, visual amenity and landscape values. These impacts can either be temporary (i.e. changes in employment) or permanent (i.e. impacts on visual amenity). Employment opportunities may be both a positive and negative impact. For instance, mining projects may compete with agriculture for skilled workforce, but off-farm employment in mining can be a valuable resilience strategy for farming businesses during severe drought.
- Indirect cumulative impacts on communities and agricultural resources due to changes in the wider Hunter Valley.

The scale and significance of these potential impacts in relation to the MCCO Project are discussed in the following sections.

6.1 Rehabilitation and Post Mining Land Use

6.1.1 Rehabilitation Objectives

The overarching rehabilitation objective is to create a safe, stable and non-polluting final landform that can co-exist with surrounding land uses. Further rehabilitation objectives for the MCCO Project Area include the following:

- Provide for the safety of employees and the public during and following the closure of the mining operations.
- Provide a safe, stable and non-polluting final landform to support associated land uses that can co-exist with surrounding land uses. This includes a commitment to the establishment of long-term landform stability and the establishment of a more natural looking and functioning landform through the use of landform design techniques such as 'micro-relief' design principles outside of the final void area, where practicable.
- Establishment of ecological rehabilitation as part of the biodiversity offset for the MCCO Project.

A key consideration for closure planning of the MCCO Project is maximising opportunities to achieve a sustainable rehabilitated landform post closure. The proposed mine closure strategy is consistent with that of the existing Mangoola Mine and the strategy for the MCCO Project integrates with the current operation.

The majority of the post-mining landscape for the MCCO Additional Project Area is proposed to be used for native vegetation and the rehabilitated landscape will aim to provide connectivity to the surrounding remnant vegetation areas. The post mining landform will be rehabilitated using selected vegetation communities that currently occur in the MCCO Additional Project Area.

The final land use for the majority of the reshaped and revegetated areas is intended to be native woodland. Small areas of agricultural land will remain along the western edge of the disturbance area adjacent to the realigned Wybong Post Office Road. Thus, no agricultural land use is planned for the vast majority of the post mining landform of the MCCO Additional Project Area. Other sections of the MCCO Additional Project Area are proposed to be used as offset areas.

6.2 Impacts on Agricultural Resources in the MCCO Additional Project Area

6.2.1 Impacts on Landform

The natural landform will be altered by the presence of a final void and reshaped overburden. The MCCO Project does not alter the broad final landform and rehabilitation objectives and practices currently undertaken at Mangoola Coal Mine. The mine closure strategy and key landform design parameters aim for the MCCO Project to integrate the post-mining landform into the surrounding environment where practicable using natural landform design principles.

The natural landform design process has successfully resulted in a more natural looking rehabilitated landform at the existing Mangoola Coal Mine, and reduced the visual impact of the final landform whilst providing a successful approach to surface water management.

The key design principles to be used in the natural landform design approach include:

- the drainage density of the final landform is to reflect the nature of the drainage patterns in surrounding landforms
- steeper slopes are to be located higher in the catchment, where water flows are smallest, with slope gradients flattening out downstream
- drainage lines will have both channel and floodplain components to provide stability during frequent flood events
- gentle flow transitions which emulate natural transitions and maintain a balance between scour risk and sediment load.

The reinstated landform will provide a landform that would be theoretically suitable for agricultural uses (i.e. grazing) outside of the final void area that is proposed. As noted above, however, the post mining land use is planned to be native vegetation / conservation for the vast majority of the MCCO Additional Project Area.

6.2.2 Impacts to Land Capability

Disturbances in the MCCO Additional Project Area will lead to changes in LSC classes due to a change in landform and soil resource. The Wybong Post Office Road realignment will result in areas that are permanently changed to infrastructure and thus will not have a LSC class.

The proposed operation will have a direct permanent impact on the majority of the area of the MCCO Additional Disturbance Area. The total area of disturbance is forecasted to be 623 ha, which includes establishment of required infrastructure, mining operations, realignment of Wybong Post Office Road and realignments to existing powerlines and infrastructure as required.

All land directly impacted is owned by Mangoola with the exception for small areas of public road reserves and Crown land. The impacted land is currently used for dryland cattle grazing or has no agricultural use. A summary of the land and soil resources of all directly impacted areas is presented in **Table 6.1**.

The proposed post mining land use is primarily native vegetation and therefore, agricultural land uses are not proposed for the vast majority of the rehabilitated area once mining has ceased and the area has been rehabilitated. **Table 6.1** splits disturbance types into final void and other disturbances. The latter includes overburden, drainage lines, power lines and topsoil stockpile areas. The final void area is expected to have a LSC Class of 8 post relinquishment, while all other areas will be LSC Class 6.

Table 6.1 Change to agricultural resources and land use in the MCCO Additional Project Area (based on EMM, 2019)

Disturbance type	Verified LSC	Area (ha)	Existing land use	Post mining LSC (indicative)	Post mining land use	Area lost to agriculture (ha)	Permanent or temporary change
Void	4	28	Dryland grazing	8	Final void and native vegetation	28	Permanent
	5	46	Dryland grazing	8		46	
	7	8	Native vegetation	8		8	
Mine disturbances (including overburden, topsoil stockpile etc.)	3	39	Dryland grazing	6	Native vegetation	39	
	4	107	Dryland grazing	6		107	
	5	356	Dryland grazing	6		356	
	7	2	Native vegetation	6		2	
Other disturbance (including infrastructure, drainage etc.)	3	1	Dryland grazing	3	Native vegetation	1	
	4	10	Dryland grazing	4		10	
	5	18	Dryland grazing	5		18	
Post Office Road Alignment	4	1	Dryland grazing	NA	Road infrastructure	1	
	5	5	Dryland grazing	NA		5	
	7	<1	Native vegetation	NA		<1	
Total area lost						623	

The main disturbance type will be related to active mining. The rehabilitated overburden is expected to have LSC Class 6 in the post mining landscape. Of the current LSC Class 3, a total of 39 ha, which is 72% of the LSC Class 3 in the MCCO Additional Project Area will be impacted and changed to LSC Class 6. Approximately 107 ha of LSC Class 4 (34% of this class) will be changed to LSC Class 6. Of the LSC Class 5, 64% (approximately 356 ha) will be reduced by one LSC Class (**Table 6.1**).

Final void areas are expected to have a LSC Class of 8, with the better land suitability (LSC Class 6) occurring at the void edge. The pre-disturbance LSC Classes for this disturbance type were LSC Class 4 (28 ha), 5 (746 ha) and 7 (8.0 ha), the total area disturbed by the final void is approximately 82 ha with no agricultural use (**Table 6.1**).

Predominately due to increased stoniness and reduced depth of topsoil profile the expected post-mining LSC Class outside the void will be LSC Class 6 (**Table 6.1**). The development of the soil profile over time due to weathering of underlying spoil decreasing rockiness and increase of nutrients through organic matter from vegetation can lead to higher land suitability. This may only occur in the long term (>100 years).

Some areas will experience minor disturbances, for example through infrastructure or drainage control. These areas are expected to retain the pre-mining LSC Classes. As the post mining land use is native vegetation, the areas which will not change LSC Class are still considered to be lost to agriculture (**Table 6.1**).

The soil verification study showed that there is no BSAL in the MCCO Additional Project area (refer to **Section 4.4.1.5**). Three small areas (<20 ha each) of land with LSC Class 3 will be disturbed by the MCCO Project. Due to the small size of each area, the value of the LSC Class 3 sections for intense agricultural use such as cropping, are limited. All other disturbed areas have moderate to severe (LSC Class 4), severe (LSC Class 5) and extremely severe (LSC Class 7) limitations to agriculture before any disturbance by mining operations occurred. If desired, much of the post mining landscape could theoretically be used for low intensity grazing, which has successfully been demonstrated at other coal mines in the Hunter Valley, however, this is not proposed.

6.2.3 Impact on Soils

Soil types directly affected by the operations within the MCCO Additional Project Area are presented in **Table 6.2**. The soil type which will have the greatest area of impact is Sodosol. Of this soil type, approximately 509 ha will be disturbed (72% of Sodosol occurring in in the MCCO Additional Project Area). The soil will be stripped and used in rehabilitation works on the site.

None of the soils in the disturbance area are highly productive. After laboratory analysis, all soils in the MCCO Additional Project Area have been classed as having a moderately low fertility. This was based on restrictions in macronutrients, micronutrients, low cation exchange capacities. Further, high sodicity and salinity pose restrictions to high intensity agriculture. For more details refer to **Section 4.4.1.3**.

Table 6.2 Soil Resources directly impacted within MCCO Additional Project Area

Disturbance activity	Soil type	Fertility*	~Area (ha)	Percentage of soil type in MCCO Additional Project Area(%)
Total	Sodosol	Moderately low	509	72
	Tenosol		69.0	27
	Kurosol		8	27
	Dermosol		38	66

* based on fertility assessment in soil assessment, see Soils Report provided as an Appendix to the MCCO Project EIS

Rehabilitation of the void, overburden emplacement area and dams involves earthworks which will result in a permanently changed landform. Changes may include a change in slope steepness and slope lengths and changes to the aspect of the slope. This will also result in altering the soil type to Anthroposols (i.e. soils derived from human activities).

While the vast majority of the post mining land use is planned to be native vegetation, i.e. no agricultural use, some areas of the post mining landform may have LSC classes suitable for low intensity grazing. Details about the current post mining landform design are presented in EIS.

Prior to mining, the topsoil reserve suitable for rehabilitation will be identified and stored for future use as per existing practices. This will provide that suitable stripping depth and stockpiling methodology will be in place which is important for rehabilitation success. Availability of topsoil suitable for rehabilitation without treatment may be limited as the disturbance footprint occurs in an area where Sodosol is the dominant soil type. This soil type is prone to erosion of topsoil (A1) and subsequent layers (bleached A2 and sodic B Horizons) have limitations to rehabilitation success if untreated.

After reshaping and topsoil application, the post mining growth medium quality (i.e. the Anthroposol) is expected to be constrained by:

- shallowness of the re-spread topsoil over the re-shaped landform
- stoniness, as soils are largely made up of the re-shaped overburden
- limited structural integrity
- fertility constraints, which are a combination of the limited fertility of the overburden and the current soil resources in the MCCO Additional Project Area.

6.2.4 Potential Physical Movement of Water away from Agriculture

In summary, based on the proposed changes to surface drainage, due to proposed additional mining activities and associated rehabilitation, the following are anticipated

- The majority of surface water flows will be directed away from the final void and towards existing drainage lines, however, some surface runoff will be captured in the void. The proposed final void in the MCCO Additional Mining Area is intended to be a long-term groundwater sink and will not spill into the surrounding drainage systems. Therefore the void is not predicted to impact on surrounding water quality.

- During operations, surface water quality is not predicted to be negatively impacted with the MCCO Project committing to implement a comprehensive surface water management plan.
- Predicted impacts to agricultural water users along Wybong Creek and Goulburn River are negligible.
- The MCCO Project will result in a negligible reduction of annual flow volumes in Wybong Creek. These reductions are well within the annual variability of flows in Wybong Creek and are negligible in the context of total flows. Thus landholders along the creek will not be affected.

Overall, the impacts of the MCCO Project on availability of surface water for agricultural users are considered to be minimal. Risks to existing agricultural enterprises are also considered negligible.

Impacts to groundwater and surface water due to the MCCO Project are further discussed in detail in the following sections.

6.2.4.1 Surface Water

The impacts to surface water, described in the following section, are based on the Surface Water Assessment carried out by HEC. The complete study can be found as an appendix of the MCCO EIS.

During operation, the surface water management plan has been designed such that no mine impacted surface water will be discharged off site in exceedance with the operations approval documents. The Surface Water Assessment concludes that the MCCO Project is not anticipated to adversely impact water quality in downstream watercourses.

With regard to flooding, relatively minor changes to flooding in Big Flat Creek are predicted and no adverse impacts on private land or on agricultural enterprises are predicted.

Based on modelled flow velocities, the risk of increased stream erosion for Big Flat Creek has generally been assessed as low with the exception of pinch points such as the proposed haulroad crossing and erosion controls are proposed in these areas to mitigate the risk of erosion.

The MCCO Additional Project Area (including the currently approved Mangoola operations) will result in reduced catchment area and hence catchment yield in Big Flat Creek and Wybong Creek. The reduction of flow in Big Flat Creek will not impact on water users as there are no private licensed surface water users downstream on Big Flat Creek. Further, Big Flat Creek is of very limited agricultural value due to water quality and its ephemeral nature (see **Section 3.4.1**).

The MCCO Project will result in a maximum reduction of the upper Wybong Creek catchment of 1.2% during year eight of operation and will settle at 0.62% of the upper Wybong Creek catchment after mining has ceased. It is expected that average total flow volumes in Wybong Creek would reduce as a result of the MCCO Additional Project Area approximately by the above percentages. A 1.2% reduction in the mean annual flow would amount to an annual average reduction of approximately 317 ML, which is less than Mangoola's total of Wybong Creek unregulated WALs.

The catchment that would be reduced through the MCCO Project currently report to Big Flat Creek. The estimated pre-mine catchment area of Big Flat Creek is 50.6 km^2, as at 2017 the catchment area was reduced to 36.5 km^2. Near the end of the MCCO Project life, it is estimated that the catchment area of Big Flat Creek would be further reduced to 23.7 km^2. After rehabilitation of the mine, the Big Flat Creek catchment would increase and is expected to be 14% smaller than the pre-mining catchment. The reductions to surface water flows caused by these reductions will not impact any surface water users as there are no private licensed surface water users on Big Flat Creek downstream of the mining operations. Baseflow reductions stemming from the MCCO Additional Project Area of up to 13 ML/year have been

predicted for Wybong Creek along its full length to the Goulburn River. This amounts to less than 0.05% of the mean annual total flow or 0.18% of the mean annual baseflow. The predicted total baseflow reduction stemming from the MCCO Project is modelled to be 28 ML/year. The total MCCO Project reduction (up to 30 ML/year) amounts to approximately 0.11% of the mean annual total flow, which represents a small and likely indiscernible impact to flow in Wybong Creek.

The reduction of baseflow for Big Flat Creek from the MCCO Additional Mining Area is predicted to be negligible.

The impacts to the Goulburn River, to which Wybong Creek is a tributary, by the MCCO Project are deemed negligible.

6.2.4.2 Groundwater

The impacts to groundwater, described in the following section, are based on the Groundwater Assessment carried out by AGE. The complete study can be found as an Appendix of the MCCO EIS.

During operation

The predicted drawdown of groundwater greater than 1 m in the alluvium, shallow colluvium and shallow regolith (2m thick) is limited to a narrow zone along Big Flat Creek. This drawdown zone extends slightly into the Wybong Creek alluvium in the cumulative mining scenario. The drawdown in these shallow groundwater zones is predominantly a result of the existing approved mining at Mangoola Coal Mine. The MCCO Proposed Additional Mining Area extends the predicted zone of drawdown slightly upstream along Big Flat Creek. The impact to the shallow groundwater systems by the MCCO Project therefore is rated as small.

Predicted drawdown of more than 1 m in the groundwater in the weathered bedrock due to the MCCO Additional Project is also confined to a zone around Big Flat Creek, however the impact area expands further upstream than the drawdown zone of the alluvium, colluvium and shallow regolith. The predicted drawdown upstream is primarily due to mining from the MCCO Proposed Additional Mining Area but the magnitude of drawdown is a combination of impacts from both the existing and proposed operations.

In summary, the predicted drawdown of the alluvium, shallow colluvium, shallow regolith and shallow weathered bedrock is spatially limited to the MCCO Additional Project Area. There are no current agricultural users of the groundwater along Big Flat Creek and thus the impact to agricultural users and enterprises is considered to be low.

Groundwater modelling predicts potential for drawdown of more than 2 m at two private bore as a result of the MCCO Project. One of these bores is located on a property in existing acquisition zone and is also predicted to exceed acquisition criteria for the MCCO Project. Should bores be affected by the MCCO Project, Mangoola will repair the affected bore, provide an alternative water supply or implement other measures agreed with the landowner.

Post closure

Modelling found that groundwater levels will gradually recover over time. In the mining and the void areas, groundwater levels are predicted to equilibrate at a lower level compared to pre-mining groundwater levels. Modelling of impacts to alluvial and surface waters showed that Big Flat Creek will remain impacted throughout the modelled 500 year post mining period, although there is a slight reduction in the reduction of surface water flux over time. The impacts to the Big Flat Creek surface water flux remain attributable to the approved Mangoola Coal Mine and not to the MCCO Project.

The value of Big Flat Creek to agriculture is limited due to its ephemeral nature and high TDS values as discussed in **Section 3.4.1**. Thus the impact to agriculture due to the impact to Big Flat Creek is low, noting this impact is already approved and not a result of the MCCO Project.

6.3 Impacts on Agricultural Resources in the Offset Areas

The agricultural resources in the offset areas will not be directly impacted as no disturbance related activities are proposed in this regard. However, the land use will change to conservation of native vegetation and ecological connectivity. This will involve regeneration of native vegetation and thus no negative impacts to soils, landform or water resources will occur.

The exclusion of grazing pressure by cattle from the proposed offset areas and the establishment of woodland vegetation is likely to positively impact the natural resources through a potential decrease of erosion and accumulation of leaf litter that will eventually be incorporated into the soil profile through decomposition. As a result, nutrient status of some soils may increase and sediment loads in waterways may decrease.

The Mangoola Coal Mine Biodiversity Offset Management Plan includes management of erosion, sediment and salinity and stipulates that appropriate measures will be taken to address erosion and salinity (Mangoola Coal Operations, 2017). These same management approaches will be applied as appropriate to the proposed offsets. At another Glencore site, Liddell Coal Mine, biodiversity offset monitoring showed an increase of the Landscape Function Analysis scores for aggregate stability, infiltration and nutrients, indicating an improvement in these soil properties (Umwelt, 2017).

The areas selected for vegetation offsets are recognised to have high biodiversity value and high potential to enhance biodiversity value. On the basis of current government policy to protect remaining areas of threatened ecological communities and other high biodiversity value aspects of the landscape, the biodiversity value of the land is considered higher than the agricultural value.

The LSC classes for the proposed offset areas were presented in **Table 4.2** in **Section 4.4.2**. Both proposed offset areas are currently used for dryland grazing for on land with LSC Class 6 and better. The complete area of both proposed offset sites has been earmarked for offsets. Therefore, the following LSC classes and areas are lost to agriculture:

- LSC Class 2: 9 ha
- LSC Class 3: 141 ha
- LSC Class 5: 1000 ha (partially located inside the MCCO Additional Project Area, but not the proposed disturbance footprint)
- LSC Class 6: 7 ha.

In addition 595 ha of LSC Class 7 and 14 ha of LSC Class 8 are also located in the proposed offset areas. Of the LSC Class 7, approximately 28 ha are located inside the MCCO Additional Project Area, but not the proposed disturbance footprint.

6.4 Impacts on Agricultural Enterprises/uses in the MCCO Additional Project Area and Proposed Offset Areas

Mangoola

Large parts of the MCCO Additional Project Area are currently used for dryland grazing, the exception being steep hillsides (LSC Class 7) and the areas occupied by rural residences or roads. The total area of disturbance is forecasted to be 623 ha, of which 612 ha is grazing land and will be lost to agriculture. In the proposed Mangoola offset area, a total of 976 ha of current grazing land (based on **Table 4.3**) is required for offsets and will be removed from agriculture. The combined loss of grazing land (forecasted mining disturbance and offsets) in the Mangoola area is therefore 1,588 ha.

Colinta manages approximately 4,649 ha of grazing land for the Mangoola Coal Operation, while 204 ha are leased out to a third party for grazing and 519 ha are cropped. The forecasted loss of grazing area accounts for 34% of the Colinta managed grazing land at Mangoola Coal Mine and 30% of the total Mangoola Coal owned agricultural land land.

In non-drought years, Colinta generally runs on average 1,200 head of cattle on the Mangoola owned land with approximately 350 of these grazed within the MCCO Additional Project Area and 150 head within the proposed Mangoola offset site outside of the MCCO Additional Project Area. At the time of this assessment, both the MCCO Additional Project Area and the proposed Mangoola offset site were destocked due to drought. The remaining herd (as of the end of 2018), 450 breeders with calves, were being grazed on more productive land to the south of Mangoola Coal Mine.

The reduction of grazing land through the MCCO Project (including the proposed biodiversity offsets) will require Colinta to vary the way it operates on Mangoola owned land. Due to the good quality of the southern grazing areas outside of the MCCO Additional Project Area and proposed offsets, the Colinta operation will be continued but at a reduced scale or with a change to operations. Such a change could include purchasing calves from other operations for fattening on Mangoola owned land.

With regard impacts to livestock from blasting activities, grazing has occurred on Mangoola land throughout the mining undertaken to date without any adverse impacts from blasting and this will continue with the MCCO Project.

Wybong Heights

The proposed Wybong Heights offset area will be completely removed from agricultural production, however, not the full extent of the Wybong Heights property will be used to form the offset site with some of the better quality agricultural land being retained in agricultural production. Based on **Table 4.3,** the proposed Wybong Heights offset area includes approximately 516 ha of grazing land. The Colinta land manager indicated the actual grazing land is less due to site limitations.

The Wybong Creek floodplain has the highest agricultural value due to soil quality and access to water. Only a small area (8.7 ha) of the floodplain is proposed to be converted to biodiversity offsets, while the majority would still be available for agriculture. The basalt plateau has high production value as well based on the mapped SLR unit, but it is reliant on bore water and dams, which have dried out in the current climate.

In non-drought years, grazing land for approximately 40% of the herd (60 head) will be lost, but grazing will be continued to be carried out in the floodplain areas which have the highest productivity.

Colinta manages two additional properties in the Wybong Heights area. Both of these properties have extensive grazing land and in average years on average 750 head of cattle are run across the all three

properties. In the latter part of 2018 that herd had been reduced to 480 cattle due to the drought conditions.

The loss of grazing land in the proposed Wybong Heights offset area results in a low impact as the loss of 60 cattle only accounts for 8% of the cattle run across the three properties run by Colinta in the Wybong Heights area.

Overall Impact on the Colinta Cattle Operation

Glencore and its subsidiary companies own approximately 285,000 ha of agricultural land in Australia, which includes about 28,000 ha in NSW. While this land is not exclusively managed for cattle, cattle grazing is the dominant form of agricultural use. A large proportion of the agricultural land is occupied by Colinta. On average, Colinta maintain at any one time between 40,000 and 50,000 cattle across Australia. Of this approximately 5,000 cattle are in NSW (Glencore, 2017).

The impacts by the proposed MCCO Project, including proposed offset areas, account for only a very small component of Colinta's operations within NSW and Australia. The breeders run on the MCCO Additional Project Area (350 head), proposed Mangoola and Wybong Heights offset sites (150 and 60 heads, respectively) make up 11% of the NSW cattle numbers and for just over 1% of the Colinta Australian herd. Therefore the MCCO Project is not predicted to result in a significant impact on Colinta's operations.

6.5 Impacts on Agricultural Resources and Uses in the Locality

The MCCO Project is situated in a rural locality which features rural and rural residential properties as well as the existing Mangoola Coal Mine. The MCCO Project will have a low impact on the agricultural resources in the locality because:

- there will be minimal impacts on the availability of water resources for agriculture outside the MCCO Additional Project Area. The MCCO Project is not predicted to impact surface water quality. For more information see **Section 6.2.4.1**
- there will be minimal impacts on groundwater quantity with two private bores predicted to be impacted with mitigation proposed so that any loses are compensated. The majority of the cumulative drawdown on all surrounding groundwater sources including the Wybong Creek alluvium is due to the existing approved operations at Mangoola Coal Mine
- modelling showed that no adverse change in groundwater quality is predicted to occur outside the mining footprint
- there will be no direct or indirect impacts to the landforms of the locality, outside of the MCCO Additional Project Area
- there will be no direct or indirect impacts to the soil resources of the locality (outside of the MCCO Additional Project Area). While BSAL is located in close proximity to the MCCO Additional Project Area, no impacts outside of the area are forecast. LSC classes in the locality will not be changed through the MCCO Project.

6.5.1 Water Resources

With regard to impacts on surface water in the locality, the key findings of relevance to agriculture include:

- the Surface Water Assessment concludes that the MCCO Project is not anticipated to adversely impact water quality in downstream watercourses

- relatively minor changes to flooding in Big Flat Creek are predicted and no adverse impacts on private land or on agricultural enterprises are predicted, or impact in Wybong Creek
- the MCCO Project will result in a negligible reduction of annual flow volumes in Wybong Creek. These reductions are well within the annual variability of flows in Wybong Creek and are negligible in the context of total flows
- no adverse impacts to downstream water users are predicted.

With regard to groundwater, the Groundwater technical study reported that predictive modelling did not show any drawdown impacts on alluvium, colluvium, shallow regolith and weathered bedrock groundwater in the locality. There will be drawdown impacts on the deeper groundwater in the locality but these deeper groundwater systems are generally poorer quality and are generally not used for agriculture.

The MCCO Project will make a very small contribution to the reduction in baseflow within Wybong Creek, however, the impact of reduced groundwater contributions to surface water is considered to be negligible (AGE, 2018).

There are a total of 15 private groundwater bores registered in the locality. Of these, two registered bores lie within the predicted areas of drawdown of over 2 m at the end of mining. These bores are used for stockwater and domestic purposes (AGE, 2019). One of these bores is located on a property in the existing acquisition zone for the mine and is also predicted to exceed acquisition criteria for the MCCO Project. Should bores be affected by the MCCO Project, Mangoola will repair the affected bore, provide an alternative water supply or implement other measures agreed with the landowner.

The Wybong Estate Vineyard is the only remaining operating vineyard in the locality. The vineyard is located upstream of the MCCO Additional Project Area. No groundwater impacts have been modelled for the location of the Wybong Estate Vineyard. There will be no impacts to the vineyard based on water resources.

6.5.2 Blasting, Noise and Air Quality

The two horse studs Coronet Farm and Golden Grove Thoroughbred are both located outside the locality. Noise and air quality modelling showed that no discernible impacts are predicted to these properties.

Further details with regard to noise and air quality modelling results are provided in the MCCO Project EIS.

The Blast Impact Assessment modelled potential ground vibration, airblast overpressure and flyrock exposure was completed for surrounding private properties. Based on this assessment, and conservative impact criteria, no concerns were detected for the wellbeing of livestock on private land surrounding the mine stemming from predicted ground vibration and blast overpressure. Given the significant distances from any blasts in the MCCO Additional Project Area to private grazing land (at least 950 m), the risk of injury to livestock from flyrock was considered to be negligible.

6.5.2.1 Land Acquisition

Modelling of noise impacts of the MCCO Project indicates that at a number of properties are predicted to exceed the acquisition criteria set in relevant NSW standards (Global Acoustics, 2018).

Properties that meet the criteria for acquisition as a result of potential impacts from the MCCO Project include seven rural properties (with a total area of approximately 370 ha).

Subject to Development Consent and if the relevant land owners decide to request acquisition of their properties, the land would become part of existing Mangoola owned land and the available productive agricultural land would be managed for agricultural purposes as a pastoral enterprise. In this case, the principal impact is one of a tenure change, rather than a land use change.

The affected land is currently not used for cropping but grazing capability occurs on five of the properties. The potential impact on agricultural enterprises and production in the locality is considered to be negligible as the productive agricultural land on these properties is expected to continue to be used for agriculture.

6.5.3 Other Socioeconomic Impacts

More generally, the main potential impacts on agricultural enterprises are associated with:

- changes to accessibility or services, which can include road access between properties or a property and supplier
- other impacts on social and economic conditions such as competing demands for skilled labour
- visual amenity.

6.5.3.1 Impacts on Services and Infrastructure

The MCCO Project will have a minimal impact on local and regional agricultural services and infrastructure. Changes to the supply and viability of agricultural support services are driven by social trends operating at a scale beyond the MCCO Project locality. The MCCO Project is predicted to result in a very small change in the number of cattle sent to the market. On average 310 calves are turned off the MCCO Additional Project Area and 140 calves from the proposed Mangoola offset areas. Due to drought, however, stock numbers were reduced this year (2018).

The closest saleyards to the MCCO Additional Project Area are located in Dubbo, Scone and Singleton. Based on the MLA Annual Saleyard Survey, 1,752,457 cattle were transacted in 39 NSW saleyards in the 2017-2018 period[11]. In the same period, cattle throughput for the saleyards in the area were:

- Dubbo: 241,282 cattle
- Scone: 73,085 cattle
- Singleton: 44,347 cattle.

If all cattle lost due to the proposed MCCO Project were not sold to the Dubbo feedlot but to one of the saleyards, the worst case scenario would be a loss of 1% of cattle (Singleton). Therefore, the impact to local saleyard due to the loss of cattle received is very small and not predicted to adversely impact the operation of any saleyards.

Wybong Post Office Road is a local road providing bi-directional traffic flows between Yarraman Road and Wybong Road. The Wybong Post Office Road is currently in a poor condition. A portion of this road is proposed to the realigned, starting at the western boundary of the MCCO Additional Project Area with Wybong Post Office Road diverting to the south to Wybong Road. The traffic and transport assessment concluded that the realignment will extend the travel distance for some users by 1.6 km and would only have a minor impact on travel times. Access along the existing road will be maintained until the

[11] https://www.mla.com.au/prices-markets/market-news/saleyard-survey-insights/, accessed 08/05/2019

realignment is constructed (GHD, 2019). Based on this assessment, the impact due to the Wybong Post Office Road realignment for agricultural enterprises is rated low.

6.5.3.2 Visual Amenity

Visual amenity is an important value in rural areas for land owners who have attachment to the rural landscape, and for enterprises that attract visitors because of the rural ambience and lifestyle experience.

For the MCCO Project, impacts to visual amenity will be limited. Local topography largely screens the proposed operation from view. There will be only limited visibility of the MCCO Project along Wybong Road and Ridgelands Road, with significant views from sections of these roads adjacent to the operations and limited views from other sections of the roads. Progressive rehabilitation is expected to reduce the visual impact from all areas where views are possible. Further, Mangoola proposes to plant tree screens along parts of Wybong Road, the realigned section of Wybong Post Office Road, and Ridgelands Road and incorporate a visual bund along Wybong Road to assist to mitigate the visual impacts.

Due to the current cessation of production of the Yarraman Estate, tourist numbers in immediate proximity to the MCCO Project are expected to be low. Visitors to the Wybong Estate Vineyard will be shielded from views of the MCCO Project by the local topography.

In this context, the impact of the MCCO Project on visual amenity of agricultural enterprises and rural properties in the locality is expected to be small and the economic value of any changes to visual amenity experienced at properties and vantage points in the locality is also expected to be small. This does not mean that there is no impact on the visual amenity or social environment of residents and landholders, but the impacts are expected to be low in the regional context.

6.5.3.3 Impact on Agricultural Employment

It is expected that the MCCO Project will result in a negligible impact on alternative agricultural uses, viticulture, rural residential or agricultural tourism land uses in the immediate vicinity. Therefore, the MCCO Project is not anticipated to negatively impact upon agricultural employment in the local area.

As the MCCO Project is proposing to continue with the existing opportunities for its operational workforce no additional impact to agricultural employment is expected.

7.0 Risks, Risk Management and Mitigation

7.1 Project Alternatives

Mangoola has undertaken detailed studies which considered alternative mine design options. The key alternative mine design options that were considered but not selected during this process included:

- mining additional coal resources to the west of the 500 kV ETL
- mining additional coal resources to the east of Ridgelands Road
- mining deeper seams below those planned to be mined by the MCCO Project
- development of a second overburden emplacement area within the MCCO Additional Project Area as an operationally more efficient alternative to hauling overburden to the south for disposal within the existing Mangoola mining area.

The MCCO Project design, however, has been selected because of:

- financial viability
- resource recovery efficiency
- efficient use of existing infrastructure and equipment fleet
- minimising noise and dust impacts on the surrounding private receivers over the life of the MCCO Project
- minimising impacts on biodiversity and water resources
- minimising social impacts
- improving the future final landform.

The proposed MCCO Project was not the option that provided the best economic return, but was determined by Mangoola to provide a good balance between economic returns and minimising impacts. The selected project option has a smaller disturbance footprint than the other options considered and therefore results in a lesser impact on agricultural land and resources. A detailed discussion of the option considered is presented in the MCCO Project EIS.

7.2 Management and Mitigation of Impacts

Mangoola has developed and implemented a comprehensive Environmental Management System (EMS) to guide the management of its activities at the mine so that environmental and social impacts are minimised and residual impacts are appropriately managed. The EMS provides a framework for managing environmental and social issues in a systematic and integrated way. It has been designed using a continuous improvement approach so that the approach to managing environmental and social issues achieves ongoing performance improvements.

The EMS includes standards, procedures, objectives and targets, which help the operation to maintain and continually improve environmental and social performance. Routine inspections and regular environmental

audits are undertaken to assess performance against objectives and targets and identify opportunities for improvement.

The EMS includes a number of environmental management plans that have been prepared and are periodically reviewed and updated to assist in the management of key environmental issues. Many of these plans have been prepared to satisfy the requirements of the Project Approval which applies to Mangoola Coal Mine and have therefore been prepared in consultation with relevant government agencies and approved for implementation by DPE. This management system will be reviewed based on the findings of the MCCO Project EIS and potential additional approval conditions. Amendments will be undertaken as required based on the additional information and subsequently applied to the existing operation as well as the MCCO Project. As a result it will continue to be a key tool to minimise impacts to agricultural lands.

Key management plans currently in effect that assist in managing impacts on agricultural lands include:

- Erosion and Sediment Control Plan – This plan provides erosion and sediment control strategies and corrective actions to prevent offsite water contamination.
- Water Management Plan - This Plan describes the surface water management strategy, provides a site water balance, and gives an overview of site water systems and water storages. It guides site water discharge, gives a summary of the water monitoring program and the surface and groundwater impact response strategy.
- Surface Water Monitoring – This plan provides surface water monitoring locations, water quality impact assessment criteria and the surface water monitoring program.
- Groundwater Monitoring Plan - This plan provides groundwater monitoring locations, water quality impact assessment criteria and the groundwater monitoring program.
- Surface Water and Groundwater Response Plan – This plan guides actions and responses if surface water or groundwater exceedance criteria are triggered.
- Noise Management Plan – This plan provides impact assessment criteria, describes noise management and mitigation measures and presents the noise monitoring program. It further guides compliance assessment and the noise exceedance protocol including corrective actions.
- Air Quality Management Plan – This plan establishes impact assessment criteria and describes air quality management controls as well as mitigation strategies. The plan sets out the air quality monitoring program and corrective actions.
- Blast Management Plan – This plan establishes impact assessment criteria, it describes blast management controls as well as mitigation strategies. The plan sets out the blast monitoring program and corrective actions.
- Biodiversity Offset Management Plan – This plan provides for appropriate land management actions across the Project Area and offset lands including weed and pest management measures.

7.3 Review of Risks

As required by the Agricultural Impact Statement technical notes a risk assessment relevant to the potential agricultural impacts associated with the MCCO Project is presented in **Table 7.1**. The risk ranking is based on the risk assessment presented in Appendix 3 of the Interim protocol (**Figure 7.1** and **Figure 7.2**).

The Initial Risk rating in **Table 7.1** is based on all conceivable risks prior to detailed investigations and outcomes of the data reviewed. The final risk rating takes into considerations findings of the technical studies and available management and mitigation options for each risk.

Consequence \ PROBABILITY	A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1. Severe and/or permanent damage. Irreversible impacts	**A1 high**	**B1 high**	**C1 high**	D1 high	E1 medium
2. Significant and /or long term damage. Long term mgt implications. Impacts difficult or impractical to reverse.	**A2 high**	**B2 high**	**C2 high**	D2 medium	E2 medium
3. Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing mgt implications which may be expensive to implement. Minor damage or impacts over the long term.	**A3 high**	**B3 high**	**C3 medium**	D3 medium	**E3 medium**
4. Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations	A4 medium	B4 medium	C4 low	D4 low	**E4 low**
5. Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations	A5 low	B5 low	C5 low	**D5 low**	**E5 low**

where:

= low risk

= medium risk

= high risk

Figure 7.1 Agricultural Impacts Risk Ranking matrix (reproduced from OEH and OASFS, 2013)

Level	Descriptor	Description
A	Almost Certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Figure 7.2 Agricultural Impact Risk Ranking probability descriptors (reproduced from OEH and OASFS, 2013)

Table 7.1 Risk assessment for impacts to agriculture by the MCCO Project

Risk	Initial Risk Rating	Findings of AIS assessment and technical studies	Additional potential mitigation measures	Final Risk Rating
Within the MCCO Additional Project Area				
Direct impact to land used for agricultural purposes	A2 - High	Open cut mining will impact on the MCCO Additional Project Area through the creation of an open cut void, out of pit overburden placement, realignment of parts of the Wybong Post Office Road and other mining related activities. While the land which will impacted by this disturbance generally has several restrictions for agricultural uses, it is has been used for grazing prior to the current drought.	Project alternatives have been thoroughly investigated.	B3 - High
Impact to BSAL	D2 – Medium	Extensive soil investigations confirmed that BSAL is not present in the MCCO Additional Project Area.		E5 - Low
Impact to land and soil Class 1 and Class 2	D2 – Medium	Extensive soil investigations confirmed that Class 1 and Class 2 land and soil is not present in the MCCO Additional Project Area.		E5 - Low
Impact to land that is moderate, moderately high or high soil fertility	C3 - Medium	Extensive soil investigations confirmed that soil fertility is predominantly moderately low.		C4 - Low
Change from non-stony to stony soils	A2 – High	Soil types in the MCCO Additional Project Area generally have a low to moderate stone content (this excludes the rolling hills which were not part of the soil investigation, but are likely to be shallow and/or stony). Anthroposols which will be present in the rehabilitated areas will predominantly stony as the majority of the soil type will be formed by overburden. Impacted soils have LSC Classes 3, 4 and 5, and have not been cultivated. Stoniness has a higher importance where there is cultivation.		C3 – Medium

Risk	Initial Risk Rating	Findings of AIS assessment and technical studies	Additional potential mitigation measures	Final Risk Rating
Impact to soil chemical characteristics	A2 – High	Extensive soil investigations showed that the soil type of large parts of the proposed disturbance area is Sodosol, which has severe chemical limitations to agriculture. While there will still be a change in the chemical characteristics between this existing soil type and the future soil type (Anthroposol), chemical characteristics of the existing soil are already poor.	Topsoil will be tested before being used for rehabilitation. Soil amendments and fertiliser will be applied as required based on laboratory results and intended vegetation community.	C4 - Low
Direct impact to existing agricultural enterprises private	D2 - Medium	No private enterprises exist in the MCCO Additional Project Area.		E5 - Low
Direct impact to existing agricultural enterprises currently managed by Colinta on Mangoola/Glencore owned land	C3 – Medium	While Colinta is using the MCCO Additional Project Area for their cattle grazing operation, the percentage of cattle run in the MCCO Additional Project Area compared to the NSW and Australian operations is low.	Colinta is likely to require a change in management approach to offset the land lost. They have the capacity and flexibility to implement management changes, so risk to successful operations is low.	B5 - Low
Direct impact to Critical Industry Clusters	D2 – Medium	No Critical Industry Clusters in the MCCO Additional Project Area.		E5 - Low
Impact to surface water	C2 – High	There will be minimal direct disturbance of Big Flat Creek itself (only works associated with infrastructure crossing of the creek) and the final landform will direct clean surface water runoff is back into Big Flat Creek. Big Flat Creek has minimal value as an agricultural resource due to its ephemeral nature and poor water quality. There are no licensed surface water users for Big Flat Creek.	The Surface Water Management System has been designed to avoid adverse impacts on downstream water quality.	C4 – Low

Risk	Initial Risk Rating	Findings of AIS assessment and technical studies	Additional potential mitigation measures	Final Risk Rating
Impacts to groundwater	B3 - High	Predicted shallow groundwater drawdown is confided to a narrow zone along Big Flat Creek and is mainly caused by the approved Mangoola Coal Mine. The additional impacts caused by the MCCO Project are comparatively small and include potential impacts to two private bores with mitigation proposed to compensate for any loses. There are no current agricultural users of the groundwater along Big Flat Creek in the area impacted and thus the impact to agricultural users and enterprises is considered to be negligible. There is no additional impact to the baseflow of Big Flat Creek alluvium and colluvium groundwater systems caused by the MCCO Project.	The Groundwater Management Plan will be implemented to monitor and manage groundwater impacts.	C4 - Low
In the Proposed Offset Areas				
Direct impact to the land	D5 – Low	No direct negative impact to land is expected through passive regeneration of the proposed offset areas. It is expected that any active regeneration works will not harm the land as that would be detrimental to achieving offset goals. It is likely that regeneration of the land will benefit soil resources.	The offset areas will be subject to a management regime that includes management of weeds, feral animals, erosion and other land management issues.	D5 – Low
Impact to BSAL	B3 – High	A total of 148.1 ha of BSAL are mapped across the proposed offset areas and approximately 217 ha, have moderate or fewer limitations to cultivation and cropping. No negative impact to the land resource will occur through the implementation of offset areas, but the land is proposed to be permanently removed from agricultural use because of its conservation value.	None required as no impacts (just change of land use).	B5 – Low

Risk	Initial Risk Rating	Findings of AIS assessment and technical studies	Additional potential mitigation measures	Final Risk Rating
Impact to CICs	B3 - High	There are 74.4 ha of Viticulture and 115.7 ha of Equine CICs mapped in the proposed offset areas in regional scale mapping (from 2012). Winegrowing occurred on approximately 6 ha in 2004 but has not been undertaken since 2013. There are no horse studs in the proposed offset areas. There are no critical industries in the proposed offset areas.		C4 - Low
Impact to surface water	D5 – Low	No negative impacts to waterways are expected. Conversely, a reduction of erosion by established vegetation may increase water quality.		D5 - Low
Direct impact to existing agricultural enterprises private	B4 - Medium	Grazing in both proposed offset areas is managed by Colinta. There are no private landholders on the land proposed for biodiversity offsets. The impact to Colinta as a state-wide and national operator is not significant.	The cumulative impact to loss of grazing land through mining and proposed offset will require the Colinta operation to adapt their management approach but overall is predicted to have a minimal impact on the Colinta operation.	B5 - Low

Risk	Initial Risk Rating	Findings of AIS assessment and technical studies	Additional potential mitigation measures	Final Risk Rating
In the locality				
Impact to downstream water users	B3 - High	Cumulative impacts of the existing and proposed operation extend under the Wybong Creek alluvium, however, the incremental drawdown from the MCCO Proposed Additional Mining under the alluvium is small. The predicted reduction of baseflow of the Wybong Creek associated with the MCCO Project is negligible. There will be an impact to four privately owned groundwater bores due to drawdown. The majority of the drawdown is contributed to the existing Mangoola Coal Mine. Changes to surface water flow of Wybong Creek associated with the MCCO Project have been predicted to be negligible and within the range of changes due to natural variability of flow. Thus, there will be no impact to downstream surface water users.	Groundwater, Surface water and Erosion management plans will be in place to assist to avoid downstream impacts to agricultural water users.	C4 - Low
Permanent / temporary impact to agriculture in the locality	C3 - Medium	There is no impact, permanent or temporary, expected to agricultural properties in the locality as a result of the MCCO Additional Project.		C4 - Low
Indirect impacts (amenity) to local farming activities (air/noise/blasting etc) in the locality	B3 – High	7 properties are subject to land acquisition due to noise exceedances (7 properties).	Impacted properties used for rural residential and grazing on native pastures. Mangoola commit to ongoing use of productive land.	C4 - Low

Risk	Initial Risk Rating	Findings of AIS assessment and technical studies	Additional potential mitigation measures	Final Risk Rating
Increased soil erosion in the locality	D3 - Medium	Modelled changes to flooding, that may lead to increased erosion are small. Controls on surface runoff will be in place, both during rehabilitation and post mining, so that there will be minimal change to sediment loads in surface runoff which may result in poor water quality offsite.		C4 - Low
Land Management (Feral animals and invasive species and bushfire)	C4 - Low	Land management at Mangoola Coal Mine is highly regulated and compliant with invasive species controls.		D4 – Low
Impact on critical industry cluster (equine or viticulture) in the locality	B3 - High	Equine and viticulture CICs are mapped in the vicinity of the MCCO Project. Two vineyards are present in the area, but only one is still operational. There are no impacts to groundwater predicted to occur in the area of the vineyard. Modelled impacts to surface water flow are within natural flow variability. No adverse air quality or blasting impacts are predicted. One horse stud is located to the north of the Project Area and another one to the south. Modelling showed that no discernible noise impacts to either farm are expected. No adverse air quality, blasting or water quality impacts are predicted at these locations.		D4- -Low
Impact on quality of BSAL land in the locality	D3 - Medium	BSAL is mapped to occur in the locality, but no off site impacts are proposed that would affect this BSAL.		C5 - Low

The majority of risks are rated low. A high risk remains for the direct impact to the land and a medium risk with the change from non-stony soils to stony. This is due to the very nature of open cut mining and subsequent rehabilitation with mine overburden. Over a long time, the stone content of the newly formed Anthroposols is likely to decrease due to weathering processes. While the area within the forecasted disturbance area will be altered and is proposed for a non-agricultural post mining land use, the pre-mining landscape had a range of limitations for agricultural use.

The risk of offsite impacts has been rated low. No impacts are expected to horse studs or vineyards in the locality. There are some groundwater drawdown impacts, which are largely associated with the existing Mangoola Mine, however, these impacts are not predicted to result in significant impacts on agriculture.

7.4 Uncertainty and Significance of Potential Impacts

7.4.1 Significance of Potential Impacts

Overall, the MCCO Project presents a medium to low risk to agricultural resources or to agricultural enterprises in the MCCO Additional Project Area and a low risk in the locality:

- risks to BSAL are low as there is no BSAL in the proposed disturbance footprint and no impacts on BSAL in the locality is expected
- risks to other agricultural resources in the disturbance footprint are low, as detailed technical studies determined that the agricultural resources in the disturbance footprint have strong limitations to agriculture
- risks to the agricultural resources of the potential offset areas are low
- risks to agricultural enterprises in the MCCO Additional Project Area and project locality are low
- risks to agricultural support services are low
- impacts and risks to the landscape character of the area are low.

7.4.2 Uncertainty

There is a high level of certainty about the relatively low quality of agricultural resources in the MCCO Additional Project Area, based on the detailed on-the-ground assessments carried out.

There is a high level of certainty about the capacity of land to be returned to a safe, stable and non-polluting post mining landform based on the MCCO Project EIS studies and evident in the actual results of the rehabilitation practices at the adjacent and approved Mangoola Coal Mine. The post mining landform itself is not proposed to have an agricultural final land use. As such, no impacts for agricultural resources and agricultural users will occur in the post mining landscape.

There is good information regarding the agricultural productivity in the locality and the broader region and the impacts of the MCCO Project on agriculture are well understood with good information regarding the agricultural use of the land provided by Colinta. Therefore, there is limited uncertainty regarding the predicted impacts of the MCCO Project on the agriculture in the locality and broader region, including indirect impacts.

8.0 References

ANZECC, 2000, National Water Quality Management Strategy: Australia Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council, October, Paper No. 4, Canberra.

Australasian Groundwater Consultants (AGE), 2018, Mangoola Coal Continued Operations Project Groundwater Impact Assessment.

Australian Bureau of Statistics, 2017a, Regional Statistics by LGA2016, Annual (2010-11 to 2015-16), Muswellbrook A 15650.

Australian Bureau of Statistics, 2017b, Regional Statistics by LGA2011-2016, Annual (2010-11 to 2015-16), Muswellbrook A 15650.

Australian Bureau of Statistics, 2017c, 71210DO004_201516 Agricultural Commodities, Australia–2015-16, Agricultural Commodities–Australia, States and Territories and ASGS regions–2015-16.

Australian Bureau of Statistics, 2017d, 75030DO005_201516 Value of Agricultural Commodities Produced, Australia–2015-16, Value of Agricultural Commodities Produced–Australia, States and Territories and ASGS regions–2015-16.

Australian Bureau of Statistics, 2017e, 71210DO007_201516 Agricultural Commodities, Australia–2015-16, Farm management and Demographics–Australia, States and Territories and ASGS regions–2015-16.

Australian Bureau of Statistics, 2012a, 71210DO005_201011, Agricultural Commodities, Australia, 2010-2011.

Australian Bureau of Statistics, 2012b, 75030DO011_201011, Value of Agricultural Commodities Produced, Australia, 2010-2011.

Australian Bureau of Statistics, 2010a, 1379.0.55.001 National Regional Profile, Muswellbrook (A), 2005-2009

Australian Bureau of Statistics, 2008a, 71250DO002_200001 Agricultural Commodities: Small Area Data, Australia, 2000-01.

Australian Bureau of Statistics, 2008b, 71250DO003_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue).

Australian Bureau of Statistics, 2008c, 71250DO001_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue) (Additional Datacubes).

Australian Bureau of Statistics, 2008d, 71250DO002_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue) (Additional Datacubes).

Australian Bureau of Statistics, 2008e, 71250DO003_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue) (Additional Datacubes).

Australian Bureau of Statistics, 2008f, 71250DO004_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue) (Additional Datacubes).

Australian Bureau of Statistics, 2008g, 71250DO005_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue).

Australian Bureau of Statistics, 2008h, 71250DO006_200506 Agricultural Commodities: Small Area Data, Australia, 2005-06 (Reissue).

Department of Planning and Infrastructure, 2016, Secretary's Environmental Assessment Requirements Yarraman Abattoir and Feedlot, Merriwa Road, Hollydeen (SSD 7645).

Department of Planning and Infrastructure, 2012, Strategic Regional Land Use Plan Upper Hunter

Department of Primary Industries (DPI), 2013a, Agricultural Impact Statement Technical Notes – A companion guide to the Agricultural Impact Statement guideline.

Department of Primary Industries (DPI), 2013b, Upper Hunter Region Viticulture Profile, Factsheet No. 5.

Department of Primary Industries (DPI), 2013c, Upper Hunter Region Agricultural Profile, Factsheet No. 1.

Department of Primary Industries (DPI), 2013d, Upper Hunter Region Beef Profile, Factsheet No. 2.

Department of Primary Industries (DPI), 2013e, Upper Hunter Region Dairy Profile, Factsheet No. 3.

Department of Primary Industries (DPI), 2013f, Upper Hunter Region Equine Profile, Factsheet No. 6.

Department of Primary Industries Water, 2016a, Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources, Wybong Creek – Rules summary sheet 38 of 38.

Department of Primary Industries Water, 2016b, Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources, Muswellbrook Water Source – Rules Summary 20 of 37.

Department of Primary Industries Water, 2016c, Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources Sydney Basin – North Coast Groundwater Source – Rules Summary Sheet 13 of 13.

Emery, K.A., 1986, Rural land capability mapping, Soil Conservation Service of NSW, Sydney.

EMM Consulting, 2019, Land and soil capability assessment

GHD, 2019, Mangoola Coal Continued Operations Project Traffic and Transport Report.

Glencore, 2017, Fact Sheet Land and Property, http://www.glencore.com.au/en/publications/fact-sheets/FactsheetsGCAA/20170504-GCAA_Fact%20Sheet%20LP_final.pdf.

Global Acoustics, 2018, Mangoola Continued Operations Project – Noise Impact Assessment.

HEC, 2019, Mangoola Coal Continued Operations Project Environmental Impact Statement Surface Water Assessment

KMH Environmental, 2016, Yarraman Abattoir and Feedlot - SSD Application Supporting Document

Kovac, M. and Lawrie, J.W., 1991, Soil landscapes of the Singleton 1:250 000 sheet, Soil Conservation Service of New South Wales.

Mangoola Coal Operations, 2017, Biodiversity Offset Management Plan and Strategy.

New South Wales Government, 2016a, Available Water Determination Order for Various NSW Unregulated and Alluvial Water Sources (No. 1)

New South Wales Government, 2016b, Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016.

New South Wales Government, 2015, Strategic Regional Land Use Policy - Guideline for Agricultural Impact Statements at the Exploration Stage

Office of Environment and Heritage, 2018, SLAM Soil Landscape Report for Hunter Region v 1.01, Thu Feb 08 13:34:42 2018.

Office of Environment and Heritage, 2014, Hunter climate change snapshot.

Office of Environment and Heritage, 2013, Land and Soil Capability mapping of NSW. Bioregional Assessment Source Dataset. Viewed 29 September 2017, http://data.bioregionalassessments.gov.au/dataset/08cacd00-81e9-4fec-8a68-c9f047bb13c8.

Office of Environment and Heritage, 2012a, Australian Soil Classification (ASC) Soil Type map of NSW, https://datasets.seed.nsw.gov.au/dataset/australian-soil-classification-asc-soil-type-map-of-nsweaa10, accessed 10/10/2018

Office of Environment and Heritage, 2012b, The Land and Soil Capability assessment scheme, Second approximation - A general rural land evaluation system for New South Wales.

Office of Environment and Heritage (OEH)and the Office of Agricultural Sustainability and Food Security (OASFS), 2013, Interim Protocol for site verification and mapping of biophysical strategic agricultural land.

Peel MC, Finlayson BL & McMahon TA (2007), Updated world map of the Köppen-Geiger climate classification, Hydrol. Earth Syst. Sci., 11, 1633-1644.

Rural Bank, 2017, Australian Dairy Annual Review June 2017, https://www.ruralbank.com.au/assets/responsive/pdf/publications/dairy-review-2017.pdf.

SLR Consulting, 2017, Mangoola Open Cut 2017 Annual Review.

Umwelt Pty Ltd, 2017, Biodiversity Offset Monitoring Report – Lidell Coal Operations, February 2017.

umwelt
Environmental & Social Consultants

Newcastle
75 York Street
Teralba NSW 2284

Perth
First Floor
12 Prowse Street
West Perth WA 6005
PO Box 783
West Perth WA 6872

Canberra
2/99 Northbourne Avenue
Turner ACT 2612
PO Box 6135
O'Connor ACT 2602

Sydney
50 York Street
Sydney NSW 2000

Brisbane
Level 13
500 Queen Street
Brisbane QLD 4000

Orange
Office 1
3 Hampden Street
Orange NSW 2800

T| 1300 793 267 E| info@umwelt.com.au www.umwelt.com.au